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FOREST LEGISLATION IN AMERICA PRIOR TO MARCH 4, 1789

BY J. P KINNEY

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CONTENTS

FOREST LEGISLATION IN AMERICA PRIOR TO MARCH 4, 1789[1]

J. P Kinney

INTRODUCTION

When the writer formed the resolution, several years ago, to write a history of the development of forest law in America, he believed that the whole period previous to the nineteenth century could be covered in a dozen pages. From the time when he began the study of forestry, in the first year of the twentieth century, the one thought that had been dominant in American forestry literature was the novelty of the propaganda for forest preservation and extension in America. A few older men knew that the need of forest conservation had been evident for a long time, but the younger students of forestry derived their ideas largely from the publications emanating from the nascent Bureau of Forestry in the national Department of Agriculture. A national conviction as to the need of forest management was developing. The new life in the Nation outshone the previous activities of the individual States.

Several writers on the development of forestry in America had mentioned a few instances of early legislation in the States or the colonies, and, either by direct statement or by implication, had suggested that these early enactments were only sporadic manifestations of the spirit of forest conservation. In searching for other instances, the writer soon found that forestry and timber problems had claimed the attention of colonial legislative bodies on many occasions during the seventeenth century, and that hundreds of such laws had been enacted previous to the establishment of the National Government. Long before the Federal Constitution became effective — on March 4, 1789 — the legislatures of most of the colonies had realized that forest fires constituted a great menace to the welfare of the people, and modern trespass laws and regulations of the lumber industry have their forerunners in the legislation of the seventeenth and eighteenth centuries. The influence of American forests in the development of the spirit of opposition to Great Britain that culminated in the Revolution of 1776 has not been given its due importance by political and economic writers, nor has it been known that certain developments of forest regulation in the colonies were strikingly anticipatory of recent movements in national forest policy.

[1] A part of a study presented to the Faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of master in forestry.

LEGISLATION REGARDING FOREST FIRES

IN MASSACHUSETTS

THE PLYMOUTH COLONY

On December 21, 1620, the Pilgrims made their first landing at Plymouth Bay, on the east coast of Massachusetts. In the following January they transferred their effects from the *Mayflower* to the rude cabins which they had constructed, and began the task of building a colony on the forested shores of New England.

Only meager records of their activities are left; yet it is known that the clearing of the forest must have progressed rapidly, for on March 29, 1626, the legislative authority for the Plymouth Colony passed an ordinance reciting the inconveniences that are likely to arise in any community from a lack of timber, and declaring that no man should sell or transport any timber whatsoever out of the colony without the approval of the governor and council. Any violation of this ordinance was to be punished by a forfeiture of the timber and by a fine of twice its value for the benefit of the Plymouth Company.[2] The crude and limited means of transportation available at that time made it imperative that a supply of timber for local uses be maintained near the colony, and justified the imposition of restrictions on the uses which the individual should be permitted to make of timber growing on common lands.

Nor was the ax of the ambitious pioneer the only menace to the forests surrounding the newly founded colony. As early as 1633 loss had been occasioned through the indiscreet firing of the woods; and in that year the setting of such fires was forbidden between the months of September and March under penalty of the payment of all damages resulting, and the firing of the woods during the remaining months was permitted only on condition that due warning be given to all neighbors.

On September 4, 1638, the setting of fires was forbidden except between February 1 and April 15, and a forfeit of ten shillings, or a whipping as an alternative, was fixed for the offense of firing the woods without just cause. This law was reenacted on October 20, 1646. The revised laws of September 29, 1658, forbade any one to fire the woods, even though he had just occasion therefor, without giving warning to his neighbors, fixed the open season for firing between February 15 and "the latter end of April," and kept the penalty of ten shillings or a whipping for an unjustified firing. These provisions were retained in substantially the same form in the revised laws of the colony as published in 1672.

[2] The various laws referred to in this bulletin are contained in full in the works listed on pages 403–405.

Under the new charter granted by King William and Queen Mary in 1691, the Plymouth Colony became a part of the Province of Massachusetts Bay.

THE MASSACHUSETTS BAY COLONY

In the records of the Massachusetts Bay Colony is found an order against the setting of fires, of an even earlier date than the first order at Plymouth. On July 26, 1631, the court of the colony, founded by John Endicott and his associates in 1628, forbade the burning of any ground prior to the 1st of March under pain of payment of full damage and such penalty as the court should see fit to inflict.

An act of November 5, 1639, in this colony imposed a fine of forty shillings, in addition to the satisfaction of all damages, on any one who should set fire on another's ground or on common ground. Whipping or other corporal punishment was to be inflicted if the offending party, whether man or woman, was unable to pay the fine or satisfy the damages. The act excepted from its penalties those who burned ground for needful or fit purposes in March or April, but made persons setting fire on their own lands liable for the damage caused others through the escape of the fire.

An act of November 4, 1646, in the Massachusetts Bay Colony, read as follows:

> Whosoev'r shall kindle any fires in ye woods before ye 10th day of ye first mo., or after ye last day of ye 2d mo., or on ye last day of ye weeke, or Lord's day, shall pay all damages yt any p'son shall lose thereby, or halfe so much to ye common treasury.[3]

The provisions of the act of 1646, with minor modifications as reenacted in 1652, remained the law in the Massachusetts Bay Colony until the creation of the Province of Massachusetts Bay in 1691, and for more than a half century thereafter. An act of May 30, 1679, made the law against the setting of fires in the woods applicable to Indians also.

THE PROVINCE OF MASSACHUSETTS BAY

An act of January 15, 1743, in the Province of Massachusetts Bay, specifically recognized the damage caused by fire to young tree growth and to the soil. This act imposed a penalty of forty shillings, for the

[3] Prior to January 1, 1752, the English people, in conformity with the Jewish chronology adopted in the Julian Calendar, were accustomed to consider the civil year as beginning on March 25 instead of on January 1, the first day of the Gregorian Calendar. During the early colonial period it was rather common, in writing any date falling between January 1 and March 24 inclusive, to include the last digit or the last two digits of the numbers expressing both the Gregorian calendar year in which this date fell and the preceding year. Thus January 5, 1653–4, and March 24, 1709–10, would denote respectively January 5, 1654, and March 24, 1710, according to the present system of chronology. However, this practice was not uniform, even in the same colony, and it is sometimes impossible to determine in which of two successive years any event took place which is recorded as occurring between January 1 and March 24. So also, in denoting the months by ordinal numerals, some writers called January the first month while others considered March the first month. Occasionally a thoughtful chronicler has added after the numeral the name of the month. It is probable that the act of November 4, 1646, cited above, considered March the first month.

benefit of the person suing for it, in addition to a liability for all damages, on any one who should willingly set fire in any woods or land lying in common within any town unless he were duly licensed by a majority vote of the town or the proprietors. The act held parents and masters liable for such damages caused by minors or servants unless satisfactory proof was presented that the minor or the servant was employed by some other person to accomplish the burning, in which case that person became liable for damages and the penalty. If towns or proprietors desired to burn lands, they must give reasonable notice within the towns where the lands were situated and also to the selectmen of adjacent towns. Because of the difficulties attendant on proof of the unlicensed setting of fires, the act provided that upon oath of the plaintiff or other creditable witness that fire had been kindled, and the presentation of circumstances making it appear highly probable that the defendant had set the fire or had caused it to be set, judgment should be given unless the defendant acquitted himself by oath, in which case he was to have costs against the plaintiff. This act was limited to three years, but subsequent acts continued it in substantially the same form until November 1, 1797.

Section 4 of a general trespass act of March 11, 1785, reenacting the substance of several separate acts passed before the institution of the Articles of Confederation, provided that if any one should willfully and maliciously make a fire with design to communicate the same to the soil, grass, trees, poles, or underbrush of another, or should willfully and maliciously suffer any fire so to communicate as to cause damage to the other to the amount of ten pounds, he should, on conviction, be fined, imprisoned, confined to hard labor, or bound to good behavior, or all of said punishments, according to the nature and aggravation of the offense.

IN NEW HAMPSHIRE

In 1639 the court at Exeter, New Hampshire, ordered that no one should fire the woods after the middle of April so as to destroy the feed of the cattle or do other hurt, under pain of paying the damages resulting.

The *General Lawes and Liberties of the Province of New Hampshire made by the General Assembly at Portsmouth, March 16, 1680*, contained a provision that no one should fire the woods between the 1st of March and the latter end of April, under penalty of making good all damages and paying a fine of ten shillings, or being set in the stocks.

IN CONNECTICUT

THE NEW HAVEN SETTLEMENTS

The revision of the laws of the New Haven Colony issued in 1644–45 provided for a fine of forty shillings, to be paid to the town by any one who should kindle a fire in his garden or any part of his house lot for the

burning of leaves, straw, cornstalks, or other rubbish, notwithstanding any excuse that he might make as to his care and attendance, the standing of the wind, or the calmness of the season.

The *New Haven Code of 1656* declared that if any one should set fire in the woods or grounds lying in common, or inclosed, so that any damage should result to another person, in any season or manner not allowed by the authority of the plantation, or on the last day of the week, or on the Lord's Day, he should pay to the plantation one and one-half times the damage caused, or, if unable to pay, be corporally punished. In 1662 the New Haven settlements were joined to the Connecticut Colony.

THE SETTLEMENTS ON THE CONNECTICUT RIVER

The *Code of Laws* of Connecticut Colony, published in 1650, forbade the setting of fires in the woods before the 10th day of the first month or after the last day of the second month, or on Saturday or Sunday, under penalty of one and one-half times the damage caused, or twenty stripes.

UNITED CONNECTICUT UNDER THE CHARTER OF 1662

A Connecticut act of May, 1733, repealed the former act regarding the firing of woods, and ordained that after August 10, 1733, any one firing the woods at any time of the year should be liable for all damages caused. The act threw the burden of proof of innocence on the defendant, but gave him double costs from the plaintiff if he established his innocence. The inhabitants of towns were permitted to burn their commons under agreement at town meetings, but they must pay all damages caused to others thereby. The Acts and Laws of Connecticut published in 1750 retained the provisions of the act of 1733.

IN RHODE ISLAND

On July 7, 1640, at Newport, Rhode Island, William Coddington, Governor, with the other assistants, agreed with the Sachem of Narragansett and the other sachems that if any Indian should build a fire at any time of the year on the lands of the Plantations and not extinguish the same on leaving it, and any damage should result, the damage should be adjudged and the Indian tried by the law of the Plantations.

On October 25, 1704, the General Assembly of Rhode Island and Providence Plantations forbade the setting of fires to burn the woods at any time "under any pretence whatsoever" other than from March 10 to May 10 of each year, or on Saturday or Sunday within this period. A violation of the act subjected the offender to a fine of thirty shillings, one-half to be paid to the complainant and one-half to the town; and an action in trespass for damages by the person injured was expressly authorized.

The penalty provided by the act of 1704 was increased to ten pounds by an act of August, 1722, with a proviso that if the offender had no personal estate with which to satisfy the fine he might be imprisoned for not over three months or be given a whipping of not over thirty-nine stripes.

An act of 1750 forbade the setting of fires "in the woods in any Part of this Colony, to run at large, at any Time or Times of the Year, under any pretence whatsoever" under penalty of fifty pounds for the first offence and one hundred pounds for the second, one-half to be paid to the informer and one-half to the poor of the town. The burden of proof of innocence was placed on the defendant and he was to be imprisoned if the fine were not paid.

IN NEW YORK

The *Duke's Laws* (published on March 1, 1665, subsequent to the capture of New Amsterdam by the English in 1664 under the direction of James, Duke of York) provided that if any one should kindle a fire in the woods or grounds lying in common, or in his own grounds so that the same should run into the lands of another, the offender should be liable for one and one-half times the damage caused, and in default of payment should be punished with twenty stripes or should do service to expiate the crime. The Dutch regained control of New York in 1673, but upon the reestablishment of the English government in the following year the Duke's Laws were again promulgated.

On November 25, 1710, a special act imposed a fine of forty shillings for the offence of firing "any uplands, plains, Woods, Trees, Shrubs, underwoods, or bushes" within the counties of Suffolk, Queens, Kings, and New York. The offender might be imprisoned for not over three months for failure to pay the fine, and he was to be liable for all damages. A similar special act of December 17, 1743, imposed a fine of five pounds, one-half to be paid to the informer and one-half to the poor fund, for firing the woods within the counties of Albany, Dutchess, and Suffolk, and in the Manor of Livingston, "at any time whatsoever," in addition to liability for all damages. The penalties of the act were applicable to one who set fire on his own land and allowed it to escape. This act empowered any person who should discover a fire in the woods of the counties or the manor named "to require and command all or any of the neighboring and adjacent inhabitants to aid & assist him" in extinguishing the fire, and imposed a forfeit of six shillings for each refusal, neglect, or delay of a person so commanded to help and assist. This act was limited to expire on June 1, 1746.

On December 16, 1758, the provisions of the act of December 17, 1743, were made the law as to the whole Colony of New York, and on the same

day a special act forbade the burning of old grass on certain beaches and islands of Suffolk County. The last-named act, which was to expire on May 1, 1760, was continued by successive acts until January 1, 1785.

A special act of unusual character was passed on November 8, 1760. This provided that the freeholders and inhabitants of the city of Albany, and of each town, manor, or precinct within the counties of Albany and Ulster, might elect at their annual town meetings such number of freeholders as they judged necessary to act as "firemen." These firemen were to have power to summon any of the inhabitants within their respective districts to assist "with all care and possible diligence" in extinguishing any forest fire within the district or the adjacent woods. Any person who without lawful excuse refused, neglected, or delayed to render such assistance when commanded, as shown by the oath of a fireman or otherwise, was to forfeit three shillings for each default, one-half to be used for the benefit of the fireman reporting and one-half for those assisting at the fire. This act was to expire on January 1, 1766.

On December 19, 1766, the provisions of the act of November 8, 1760, were reenacted and extended to include the county of Orange. An additional clause imposed a fine of two pounds for every default or neglect of a fireman to do his duty. This act was limited to expire on January 1, 1777.

On March 12, 1788, all prior general acts regarding the firing of the woods were repealed, and a penalty of ten pounds, in addition to damages, was imposed for the offenses defined by the act of December 16, 1758. This act required the justices of the peace, the supervisor, the commissioners of highways, and the officers of the militia not under the rank of captain, residing in a town where the woods were on fire, to order as many as they should deem necessary of the inhabitants of the town liable to work on highways, to assist in extinguishing the fire; and any person so ordered who should refuse or neglect to comply should forfeit four shillings for every day of neglect or refusal, with costs of recovery, and the oath of the person who gave the order was to be sufficient evidence for a conviction. The forfeiture recovered was to be used as a reward to such person or persons as a major part of the officers aforesaid should deem best entitled thereto, for superior exertions in extinguishing the fire.

IN NEW JERSEY

In 1683 the General Assembly at Burlington, in West Jersey, forbade any one from thenceforth to fire the woods before the 20th day of the twelfth month, under penalty of paying all damages and also of being fined not to exceed forty shillings. Firing within one's own lands was excepted from the penalties, provided that care was taken to prevent the fire from running outside and that no damage was done to the property of another person.

A New Jersey act of January 26, 1717, contained the same penalties and provisions as the act of 1683, except that the open season for firing was limited to the period from February 14 to April 14 of each year. This act made it clear that a person setting fire with care on his own land within this period was liable only for damages if the fire escaped from his control, while every person was liable for all damages caused by a fire set at any other time of the year.

An act of July 31, 1740, which specifically repealed the act of 1717, provided that if a person should set fire to his own woods at any time he should pay all damages suffered by another; and if he should set fire to woods not belonging to himself he should pay all damages suffered by any one, and forfeit forty shillings and costs to any one who should prosecute for the offense. Thus New Jersey, like other provinces and colonies, was compelled to give up the idea of an open season for burning, make all persons responsible at all times of the year for any damage caused by fires that they should set, and hold a severe penalty over the heads of those reckless ones who were accustomed to setting fires on the property of others.

On June 20, 1765, it was enacted that any one found guilty after February 1, 1766, of violating the provisions of the act of July 31, 1740, should be fined twenty pounds, or, if unable to pay the fine and costs, should be liable to imprisonment at the discretion of the county court, and justices and grand juries were urged to activity in the discovery of offenders.

IN PENNSYLVANIA

The first Assembly in the Province of Pennsylvania convened on March 10, 1683, and on March 20, 1683, passed a bill which provided that if any one should set a fire before the first day of the first month yearly he should make good all damages which should result from such act. An act of November 27, 1700, included the additional limitation that no fires should be set after the first day of the third month.

On March 27, 1713, the act of November 27, 1700, was amended so as to require a twenty-four-hours notice to the owner of any fence or building within one mile of which a fire was set, even within the seasonable limits allowed for burning by the act of 1700.

An act passed in the eighth year of the reign of George II (on March 29, 1735) referred to the act of November 27, 1700, stated that experience had shown "that the setting the woods on Fire at any time hath proved rather hurtful than beneficial to this Province, and great Losses have happened by Occasion of such Fire," repealed the previous act, and provided that thereafter every person should be liable for all damages caused by a fire which he should set, or cause to be set, at any time. The last clause of this act provided that if the offense were committed by any

servant, Negro, or slave without the direction of his, her, or their master or mistress, and the master or mistress should refuse to pay the damages and costs, the offender should receive not over twenty-one stripes "on his or her bare back" at the discretion of the justice, and should be committed to the county workhouse until the costs of the prosecution were paid.

IN DELAWARE

The provisions of the Duke's Laws regarding the firing of the woods as issued at New York on March 1, 1665, were applicable to the settlements on the Delaware, which fell into the control of the English at the same time as did New Netherland. Subsequent to 1682 these settlements were under the jurisdiction of Pennsylvania, but they were given a separate assembly in 1702.

An act of the Delaware Assembly in 1739 declared that whoever should fire the woods to the damage of another person, before March 10 or after May 1, should forfeit five pounds and costs, one-half to be paid to the poor and one-half to the informer, besides damages to the person injured; and if the offender lacked goods to make satisfaction, he should be liable to servitude. A Negro or a mulatto was to receive thirty-one lashes for the offense, and there appears to have been no alternative provision. An act of 1741 specified certain areas in which one would incur the penalties of the act of 1739 for setting fire at any time to the damage of another.

IN NORTH CAROLINA

In chapter 25 of the Acts of 1777, State of North Carolina, it is declared that the burning of the woods is "destructive to cattle and hogs, extremely prejudicial to Soil, and oftentimes of fatal consequences to Planters and Farmers, by destroying their fences and other Improvements." Section 2 of this act made it unlawful to fire the woods except on one's own property, and then notice must first be given to adjacent owners at least two days before the firing and effectual care must be taken to extinguish the fire before it could reach any vacant or unpatented lands. Section 3 imposed penalties for offenders, and section 4 provided that any slave, free Negro or mulatto, or vagrant person, who should be unable to pay the fine, was to "receive on his bare Back thirty-nine Lashes, well laid on."[4]

Chapter 29 of the Laws of 1782 declared that the penalties in the act of 1777 were insufficient, and amended section 3 by imposing a fine of twenty-five pounds for each offense, to be recovered "by Action of Debt, Bill, Plaint, or Information to use of person who shall sue or prosecute for the same," and the offender was further liable to the injured party for all damages suffered.

[4] Whipping of free persons was repealed by chapter 182, Laws of 1782.

GENERAL LEGISLATION DIRECTED TOWARD THE CONSERVATION OF TIMBER AND THE PREVENTION OF TRESPASS

IN MASSACHUSETTS

THE PLYMOUTH COLONY

The first legislation in America having as an object the conservation of the supply of timber appears to have been the order of the Plymouth Court, dated March 29, 1626, to which reference has already been made (page 363). The need of conserving the timber resources through a prevention of waste and a supervision of utilization became more apparent as the years passed.

The ordinances of the Plymouth Colony as revised and published in October, 1636, forbade any person to sell out of the colony any boards, plank, or timber cut from the swamps reserved for public use, without leave from the public authorities. On June 29, 1652, the General Court at Plymouth ordered that whosoever should saw any boards at any place within the colony not in the bounds of any particular town should pay the Government twenty pence for every thousand feet of timber or plank. The General Laws of Plymouth Colony as revised and issued on September 29, 1658, retained the prohibition of the laws of 1636 against the sale of timber from the reserved swamps, referred to the loss that the country suffered because some persons were accustomed to fell timber on the common and allow it to waste, and enacted that any person who should fell such timber and not square nor rive it within six months should forfeit the same to the use of any one who should see fit to take it. This provision was reenacted in the General Laws as revised and published in 1672.

In 1669 it was ordered that no bark nor boards should be transported out of the colony, nor any kind of timber except that which was wrought into vessels or casks, on penalty of the forfeiture of the same to the colony; and an act of 1672 forbade the exportation of bark or unmanufactured timber out of Plymouth Colony during a period of seven years, under penalty of the forfeiture of the same or its value. The penalties were not to be imposed if the shipper proved that the timber or bark came from his own lands.

A Plymouth order of 1670 stated that several towns of the colony were already much straitened for building timber, and granted such towns the privilege of obtaining it from towns having plenty.

THE MASSACHUSETTS BAY COLONY

Similar solicitude as to the necessity of controlling the use of the forests was felt in the Massachusetts Bay Colony, established in 1628; and on November 7, 1632, the Court at Boston, in order to preserve good timber for the more necessary uses, ordered that no one should fell any

wood on public grounds for paling except such as had been viewed and allowed by the proper public official. The prohibition of the exportation of timber from this colony, which had earlier been imposed, was repealed in 1640. In 1660 the right of commonage in wood and timber was restricted to those already having the right and those to whom the inhabitants of the towns should extend it by a vote.

UNDER THE PROVINCIAL CHARTER OF 1691 AND THE CONFEDERATION

An act of March 2, 1694, in the Massachusetts Bay Province, forbade any one to cut trees from the lands of another or from the common of a town in which he did not have a right of commonage, without license, under a penalty of twenty shillings for every tree above one foot in diameter and ten shillings for every tree of smaller diameter. A second offense was punished by an additional fine of twenty shillings for the benefit of the poor of the town. These penalties were repeated in an act of June 10, 1698, with a further provision of treble damages for other wood or underwood.

In 1726 the penalties for cutting trees from the lands of others in the Massachusetts Province were increased to forty shillings for every tree one foot in diameter and for all trees of greater diameter three times their value besides the forty shillings, to twenty shillings for every tree or pole under one foot in diameter, and for wood and underwood treble its value. If the oath of the complainant were supported by circumstances making it highly probable that the defendant had committed the trespass, the burden of proof was on the defendant to avoid judgment.

A Massachusetts trespass act of November 23, 1785, reads in part as follows:

> That if any person shall cut down, destroy or carry away any tree or trees whatever, placed or growing for use, shade or ornament; or any timber, wood or underwood, standing, lying or growing on land not his own; not having the consent of the owner thereof,.................................the person so offending, shall forfeit and pay for each tree or stick of timber so cut down, destroyed or carried away................ a fine not less than Five, nor more than Forty Shillings, to the use of the Commonwealth,.....................and shall be liable to answer in damages to the party injured.

This act provided that if any person, being indicted and sentenced, was unable to pay the fine, the court might order "such person to be publicly whipped, not exceeding twenty stripes, or be imprisoned not exceeding ninety days, and to find sureties for his good behavior for the term of one year."

On October 24, 1783, the General Court passed an act forbidding the cutting or destroying of white pine trees twenty-four inches or upward in diameter twelve inches from the ground, from any lands of the State, without previous license from the Legislature, under penalty of thirty pounds; and the penalty was incurred by any one who should aid or as-

sist in such cutting or destruction or in the drawing away of trees so cut or felled. This act also fixed a penalty of three pounds for the unlawful taking of any pine tree less than twenty-four inches in diameter twelve inches from the ground. Two-thirds of the penalties recovered went to the Commonwealth and one-third to the informer. This law was strikingly similar to the one that had aroused such opposition on the part of the colonists of New Hampshire when imposed by direction of the Crown during the colonial period. However, it should be observed that the colonists stated their grievances as consisting largely in the fact that the royal surveyor-general did not promptly select and mark the trees to be reserved for the navy, and that thus vast quantities of timber which were not needed for naval purposes were tied up uselessly, to the disadvantage of all.

IN NEW HAMPSHIRE

In the year 1640, at the newly founded town of Exeter within what later became the State of New Hampshire, the inhabitants voted that no one should fell any oak within a half mile of the town, except on his own planting lot or for buildings or fences, under penalty of five shillings for each tree unlawfully felled. In 1660, at Portsmouth, New Hampshire, a fine of five shillings was imposed for every tree cut by the inhabitants except for their own buildings, fences, and firewood; and in the towns of Kittery and Dover strict limitations were put on the number of trees that a person could have, felled and unmanufactured, at one time, the limit at Dover being ten, with a forfeit of ten shillings for every tree in excess of this number.

In providing for a settlement of the boundaries of Exeter, New Hampshire, in 1667, the General Court ordered that all pine trees fit for masts, twenty-four inches in diameter three feet from the ground, growing more than three miles from the Exeter meetinghouse and within the boundaries of the town, should be reserved for the public; and the Court fixed a penalty of ten pounds for each tree of this character that should be unlawfully felled, one-half of the penalty to go to the informer and one-half to the treasury of the county.

At Hampton on May 13, 1680, selectmen were chosen to act for the town in general matters, but these men were prohibited from disposing of any timber, this being a matter that rested with the freemen of the town; and at the same town on June 12, 1680, the freemen chose three men who were "to prosecute by way of suit or other ways, against any person or persons that shall trespass or have trespassed upon the town's rights, either in timber or land, by fencing or in other ways."

A New Hampshire act of October 8, 1697, fixed a penalty of five shillings for every tree cut without leave on the land of another, the fine to be

paid to the person damaged, and imposed a fine of from forty shillings to one crown for the cutting of a marked boundary tree. A general trespass act of the same year was broad enough to include injury to trees.

An act for preventing trespasses, passed on October 16, 1707, required that any person who should without permission cut trees from the lands of another should pay to the party injured twenty shillings for every tree one foot or over in diameter, ten shillings for smaller trees, and treble its value for wood and underwood. For a second offense, in addition to the above forfeit and damages to the injured party, the offender must pay a forfeit of twenty shillings to the poor fund or suffer one month imprisonment. Children or servants for whose offenses the parents or the master refused to answer might be whipped or set in the stocks or the cage.

An act of the General Court in 1718 imposed for each tree a penalty of twenty shillings or more, according to its value, to be paid to the party damaged, and ordained that "the Owners shall be accounted those, or such as derive a right from those to whom the Land upon which said Trees grow, is laid out, and bounded by the Layers out of Land chosen in each town," except where the right to the timber was in one person and that to the land in another, in which case the damage went to the owner of the timber. The act was not to apply to trees cut for the use of the royal navy.

IN CONNECTICUT

THE NEW HAVEN SETTLEMENTS

The need of controlling the cutting of timber on public lands was recognized also in the settlements in Connecticut. An order issued on November 25, 1639, by the General Court of the New Haven Colony, founded in 1638, forbade any one to cut timber from common ground except where assigned by the magistrate, and appointed two men to search the woods for timber that had been cut but not crosscut nor squared, and authorized them to seize the same, one-half for themselves and one-half for the town. In 1640 the General Court imposed a fine of twenty shillings for each offense of cutting a tree where spruce masts grew. In 1642 the General Court declared that whoever should without leave cut a tree standing on any common within two miles of any part of the town, should lose the tree and his labor and suffer a fine of one shilling; and if he should carry away the tree or a part of it he should pay such further damage as the Court should judge proper. An order of February 24, 1644, was directed toward an enforcement of the order of 1642; and one of June 16, 1645, appointed men who should supervise the getting of bark for tanning purposes, to the end that damage to the forests should be prevented as much as possible.

The revised New Haven laws of 1644-45 repealed the order of 1640 imposing a fine of twenty shillings for cutting a tree where spruce masts

grew; but on January 31, 1647, the General Court ordered that no man should fell any tree within the common of the town of New Haven, without leave from some magistrate, and that even then he should have the wood only for his particular trade or necessary use. This order also provided that if timber thus cut down were left unused for more than fourteen days, it should be forfeited to the use of any one whom the magistrate might give leave to take it.

THE SETTLEMENTS ON THE CONNECTICUT RIVER

On September 10, 1640, in the fourth year of the settlement at Hartford, Connecticut, the General Court forbade the felling of timber on the commons without a license from the particular court having jurisdiction, and prohibited the selling of pipestaves for exportation to foreign markets unless the same were viewed and approved by a committee to be appointed by the court. On September 9, 1641, the previous order was modified so as to permit the felling of timber on the commons, except within three miles of the mouth of the Matabezeke River, provided the timber was felled between the end of September and the beginning of April, worked up within one month after felling, and transported out of the colony only in exchange for necessary provisions brought in. These requirements were reenacted in the *Code of Laws* promulgated in 1650.

UNITED CONNECTICUT UNDER THE CHARTER OF 1662

A Court of Election held at Hartford, Connecticut, on May 12, 1687, forbade the transportation of timber out of any township of the colony without the consent of the town, under penalty of the forfeiture of the timber, and decreed that the master of any vessel who should receive on board any timber without the required license should forfeit forty shillings for every breach of the order. This order was not to apply to sawmills erected with the consent of the General Court. The same order provided a forfeit of five shillings for every tree that should be cut on the common by a tanner for the bark, without license first obtained from the town. On October 12, 1699, the General Assembly at Hartford enacted a law similar in its prohibitions and penalties to the order of May 12, 1687, but requiring that a license for exportation must be "in writing under the hands of the major part of the selectmen of the town."

At a general assembly begun at Hartford on May 8, 1718, it was enacted that any one who should cut any tree "on the land which appears to be the property of any other person or persons, and hath been formerly bounded out, and the lines between corner and corner marked out or renewed within four years next before the felling of such tree, without leave first obtained from such owner or owners, under his or their hands," should pay to the

owner "for each tree or stadle under one foot over at the stub, five shillings; for each tree which is one foot and under two foot, ten shillings; and for each tree two foot over or more at stub, twenty shillings, over and above the value of the trees so felled." Agreements of towns were specifically saved from the prohibition of the act.

In October, 1726, the Assembly forbade any person, after December 31, 1726, to "cut, fell, destroy or carry away, any tree or trees, timber or underwood whatsoever, standing, lying or growing on the land of any other person or persons, or off or from any sequestered land for town commons, or any common or undivided lands in any town, without leave or license of the owner or owners of such lands, ..." on pain of a forfeit to the party injured of "twenty shillings for every tree of one foot over, and for all trees of greater dimensions three times the value thereof besides twenty shillings as aforesaid, and ten shillings for every tree or pole under the dimensions of one foot diameter." The inhabitants of the respective towns were entitled to the penalties if the timber was cut from lands sequestered for town commons, and the proprietors of the lands were entitled to those derived from cutting on "common and undivided lands." If the plaintiff merely made it appear to the Court highly probable that the defendant had committed the offense, the plaintiff should have judgment unless the defendant acquitted himself under oath; in the latter case, the defendant should have judgment for double costs. The proprietors of undivided lands and the inhabitants of towns holding sequestered commons could dispose of their timber as they saw fit, but only reasonable restrictions could be imposed as to the getting of firewood or fencing stuff for personal use by any inhabitant from a town common. Under the act an offender was liable for only the just value of the timber if he proved that he believed he was entitled to it at the time of cutting or taking. The act was limited to substantially two years. An act to explain a special exception in this act was passed in October, 1734. The Acts and Laws published at New London in 1750 reduced the penalties to five shillings for trees under one foot, ten shillings for those of one foot, and treble their value plus ten shillings for those of larger diameter.

IN RHODE ISLAND

THE PROVIDENCE PLANTATIONS

An order of February 28, 1638, in the Providence Plantations, which had been founded in 1636, required that two men should view the timber on the common and determine what was best suited for the use of each person. This order provided for a forfeiture to the town of timber that any one should permit to lie on the ground for more than one year after felling. Orders of November 27, 1650, and December 11, 1666, imposed fines for the

taking of timber from the commons without the consent of the town, and one of 1651 forbade the cutting of timber on the common purposely for goats.

THE NEWPORT SETTLEMENT

A court held at Newport, Rhode Island, in 1639, expressly forbade two parties who were engaged in sawing lumber from exporting any timber from the town of Newport without license from the authorities.

THE PORTSMOUTH SETTLEMENT

In 1640, at a public meeting at Portsmouth, liberty was granted for the exportation of a shipload of pipestaves, clapboards, and other articles, under the direction of the town.

THE UNITED SETTLEMENTS IN RHODE ISLAND

An order of May, 1647, applicable to the settlements of Providence, Newport, Portsmouth, and Warwick, imposed treble damages and costs, or servitude in the house of correction, for the offense of trespassing on timber.

On February 6, 1710, the authorities of the Rhode Island and Providence Plantations forbade the cutting down or carrying away of cedar, pine, or other timber from the commons without a proper grant from the proprietors of the Plantations, and in 1714 a fine of five shillings was imposed for every tree or pole cut from the land of another without the owner's permission.

An act directed against persons who cut timber from the lands of others without leave, was passed at a session of the General Assembly of Rhode Island and Providence Plantations beginning on February 14, 1743. This act imposed a fine of twenty shillings plus treble its value for every tree one foot or over, ten shillings for every tree under one foot, and for other wood or underwood treble its value. The second section of the act placed the burden of proof on the defendant after the plaintiff had taken oath that the trees were cut or destroyed as mentioned in the writ by number, and that he suspected the defendant and the circumstances supported this view. However, if the defendant acquitted himself the plaintiff was to pay double costs.

IN NEW YORK

In New York an act of May 16, 1699, aimed to prevent timber trespass on the commons and on private property. This act fixed penalties for the unlawful cutting of timber, of twenty shillings for every tree one foot or over in diameter, six shillings for every tree or pole under that size, "and for other wood or underwood the value thereof," to the party injured. The act provided further that if an offender were convicted a

second time he should, in addition to the above forfeitures and damage to the party injured, forfeit to the town in which the offense was committed the sum of forty shillings, or suffer one month imprisonment. The city and county of Albany and the county of Ulster were exempted from the provisions of this act, but an act of December 24, 1759, extended the limitations of the former act to Ulster County.

The first legislative recognition in America of the principle of timber conservation through the imposition of a diameter limit for cutting, except the acts that were enforced by the requirements of the parliamentary act directed at the maintenance of a supply of mast timber, was by an act passed at Albany on March 24, 1772. This act forbade any person or persons whatsoever, either by themselves, their servants, or their slaves, to bring into the city of Albany or into a specified part of the Manor of Rensselaerwyck, "any Wood to be used as firewood, ... either for sale or otherwise, under the Diameter of six Inches if such Wood be of the Pine kind, and four Inches Diameter if of any other kind of Wood at the Stump end on Penalty of forfeiting and paying the Sum of Six Shillings for every Load of Wood which shall contain more than six Sticks or Pieces of Wood under the size aforesaid," the penalties to be used for public purposes of the city and county of Albany.

IN NEW JERSEY

On June 23, 1666, at Elizabeth Town, in the newly established proprietary of New Jersey, it was decreed by Governor Philip Carteret and his Council that no one should cut any timber trees useful for building, fences, or the making of pipestaves, on any lands not their own, nor within three miles of any home lot belonging to the town, without license from the Governor or the owners of the land, under penalty of forfeiting five pounds sterling for every tree so felled.

A General Assembly at Elizabethtown on October 21, 1678, imposed a penalty of five pounds for every tree cut from unpatented lands, one-third of the fine to go to the informer and two-thirds to the public treasury.

At the first session of the General Assembly for West Jersey, convened on November 9, 1681, it was enacted that no one should fell or carry away timber from any land surveyed within the province, without leave of the owner, under pain of treble damages.

At a council held at Elizabethtown in East Jersey on December 1, 1683, a resolution was adopted reciting that much timber trespass and waste was being committed, and authorizing the Governor to issue a proclamation and enforce the law against timber trespass.

A council held at Burlington, New Jersey, in February, 1710, considered a bill entitled "An Act for preventing the Waste of Timber and Pine

Trees, Poles and Pine Knots within this province of New Jersey." This bill did not become a law, but a similar one including cedar trees became a law on March 11, 1714. This act recited that there had been great waste through the cutting and carrying away of timber, the boring of trees, and the extracting of turpentine, both on the lands of the proprietors and of others, and expressed the belief that the exportation of pipe and hogshead staves to neighboring provinces would both destroy the timber and discourage trade. The act accordingly imposed penalties of twenty shillings for each tree cut, bored, or boxed on the land of another, and ten shillings for every pine or cedar pole cut. Cutting on the commons was excepted from the penalties.

The penalties of the act of March 11, 1714, did not prove sufficient to prevent timber trespass, and in 1759 it was enacted that any person who should cut, box, bore, or destroy any tree, sapling, or pole, on lands to which he did not have right or title, should forfeit twenty shillings in addition to the penalties inflicted by the act of 1713–14. The operation of this additional penalty was limited to five years. There appear to have been other temporary acts imposing additional penalties, and on December 21, 1771, not only was the additional penalty of twenty shillings imposed, but the time within which prosecution might be brought was extended from the six months named in the act of 1713–14 to eighteen months. The act of 1771 was limited to seven years.

On March 18, 1780, the Council and General Assembly of the newly organized State of New Jersey passed an act which recited that the act of 1713-14 and the acts supplementary thereto had by experience been found beneficial to the interests of the State, but that the penalties therein had of late proved insufficient; and, since the supplementary acts had expired by limitation, it was enacted that for each tree, sapling, or pole cut, felled, worked up, carried away, boxed, bored, or destroyed on any land within the State, without permission, by any person who had no right or title thereto, a penalty of fifty pounds should be paid. Section 2 provided that judgment and execution should be given even though the defendant claimed the land, unless he gave bond in the sum of one thousand pounds for appearance in an action of trespass. Eighteen months were allowed for the bringing of actions, and the act of March 11, 1714, was repealed. This later act appears to have overshot the mark in the matter of penalty and bond, for on June 13, 1783, an act was passed which fixed the penalty for the same offenses as those mentioned in the act of 1780 at three pounds for each tree, sapling, or pole, allowed eighteen months for prosecution, and fixed the bond in cases in which the defendant claimed the land at double the amount of the claim. Section 2 made subject to the penalty of the act any one who should saw a log which he knew to

have been stolen. The cutting of trees for the repair of a highway was specially excepted from the prohibition of the act, and the act of 1713–14 was again repealed.

IN PENNSYLVANIA

Prior to establishing a colony in the vast proprietary domain that had received the name *Penn's Woods* because of the magnificent forests which were known to lie within it, William Penn published in England a fundamental document, of which section 11 declared that all deeds should include all woods and underwoods, and section 18 provided that care must be taken to leave one acre of trees for every five acres cleared, and especially to preserve oak and mulberry for silk and shipping.

In the first Assembly, on March 30, 1683, a resolution forbidding any one to fell the trees of another person was adopted, and at a session begun at Newcastle on October 14, 1700, a forfeit of five pounds to the owner was prescribed for the cutting of a black walnut tree, one of fifty shillings for any other timber tree, and double its value for firewood or underwood. On March 17, 1780, trespassers on timber were made liable to fine and imprisonment in addition to the payment of treble damages to the owner of the land, whether the owner was a private party or the commonwealth.

IN DELAWARE

In Delaware an act of 1741 declared that any one cutting down any "timber tree or trees" on the lands of another should pay the injured party fifty shillings and costs. For failure to pay this penalty the offender could be required to make satisfaction by servitude for a period not exceeding four years. A timber tree was defined as a tree one foot or over in diameter two feet from the ground. The cutting of "firewood or underwood" must be satisfied by treble damages and costs, or by servitude. This act repealed one previously in force. It will be remembered that Delaware had been governed by the laws of Pennsylvania prior to 1702, and that those laws were effective in Delaware until they were repealed.

IN MARYLAND

A Maryland act of June 2, 1692, granting certain free use of timber to any one who should build a mill, excepted timber fit to "split or cleave into clapboards." An act of September 21, 1704, declared that grantees of land lying within the land of the Indians should have an action of trespass against any one who should cut timber therefrom under pretence of having bought it from the Indians. An act of 1724, authorizing the free use of timber for repair of highways, excepted trees fit for clapboards or coopers' timber.

REGULATION OF THE LUMBER AND TIMBER INDUSTRY

The extent to which the authorities exercised control over manufacture and trade in lumber in the colonial period presents a striking contrast to the *laissez faire* policy of the nineteenth century.

STATUTORY PRICES FOR LUMBER AND TIMBER PRODUCTS

On September 27, 1631, the Court of Assistants at Boston ordered that sawyers should not take over twelve pence a score for sawing boards if the wood were felled and squared for them, and not over seven shillings per hundred if they felled and squared the timber themselves.

At Newport, Rhode Island, in 1639, Ralph Earle and his copartner, Mr. Willbore, were required to furnish the town with sawed boards at eight shillings per hundred and with half-inch boards at seven shillings per hundred, delivered by the pit at the waterside; and with clapboards at twelve pence a foot.

On June 7, 1641, the General Court at Hartford, Connecticut, ordered that sawyers should not take over four shillings and two pence for slit work on three-inch planks, or over three shillings and six pence for boards by the hundred; and that boards should be sold for not over five shillings and six pence per hundred.

In 1669 the Court of Plymouth declared that no boards should be brought into the colony or sold at a price above forty-five shillings per thousand at the waterside where sawed, under a fine of ten shillings per thousand.

REGULATION OF THE SALE OF FIREWOOD

The standard cord of firewood — 8 feet long, 4 feet broad, and 4 feet high — was established by law in the Massachusetts Bay Colony in 1647, in New York in 1684, in Rhode Island in 1698, in South Carolina in 1738, in Delaware in 1741, in Georgia in 1766, and in North Carolina in 1784; and provision for official wood-corders was made in Massachusetts in 1655, in Rhode Island in 1698, and in New Hampshire in 1714. There was subsequent legislation on the same subject in practically all of these colonies.

INSPECTION OF TIMBER PRODUCTS, AND EXPORT DUTIES THEREON

IN MASSACHUSETTS

THE MASSACHUSETTS BAY COLONY

An order of 1641 prescribed the length and quality of pipestaves that were to be offered for exportation from the Massachusetts Bay Colony. This order did not prove sufficient, and on November 4, 1646, the General

Court, after reciting the evils to foreign trade which would result from the exportation of pipestaves of poor quality, especially on account of wormholes, ordered that the selectmen of Boston, Charlestown, and all other towns from which pipestaves were shipped, should from time to time, as should be necessary, choose viewers who should be sworn to faithfully inspect all pipestaves intended for exportation to Spain or Portugal, or to the dominions of either nation. All material that did not, in the opinion of the viewers, conform to the standards required by the trade, was to be forfeited. Any master or officer of a ship who should receive material in evasion of the order was liable to a forfeit of five pounds sterling for every thousand staves so received. A supplementary act of May 19, 1669, specified more particularly the sizes and qualities required for white oak and red oak staves.

On June 2, 1653, the General Court granted a request of Boston and Charlestown that selectmen in those towns be permitted to appoint persons to measure lumber, and an act of May 23, 1655, authorized the selectmen of Boston, Charlestown, Salem, and such other towns as should think fit, to appoint persons who should be sworn to faithfully and uprightly measure wood and boards, and no one was to be required to receive such articles until measured by these officials.

THE PROVINCE OF MASSACHUSETTS BAY

A Massachusetts act of June 18, 1695, provided that any purchaser of shingles might apply to a justice of the peace, who should thereupon appoint some able house carpenter, who should under oath view the shingles and seize, for the benefit of the poor of the town, bundles containing shingles that did not conform to the standard sizes of 15 or 18 inches long, $3\frac{1}{2}$ inches wide, and $\frac{1}{2}$ inch thick, or that were not well shaved. An act of June 21, 1710, provided for the annual election, in every town of the province where boards, plank, timber, or slit work were imported or exported, of two or more surveyors, who were to receive fees for inspecting timber products. Cull material was to be burned or forfeited for the poor.

On June 23, 1727, the General Court said there had been abuses of the former acts, provided in greater detail for inspection, and required that the brand of the town where they were inspected should be placed on every bundle of shingles or clapboards. No shingle was to be under 3 inches wide, and the average was to be $4\frac{1}{2}$ inches. The shingles were to be either 15 or 18 inches long, "as sold for," $\frac{1}{2}$ inch thick at the butt, and well shaved so as to be free from winding. Clapboards exposed for sale must be of sound timber, $\frac{5}{8}$ of an inch thick, 5 inches wide, 4 feet 6 inches long, straight, and well shaved. The surveyors were to be ap-

pointed annually by the justices of the peace and were subject to a fine for refusal to serve. The act was to be effective for a period of four years, beginning January 1, 1728, but an act passed on January 4, 1738, was substantially the same as that of June 23, 1727, and another of the same day regulated the quality and sizes of pipe, barrel, and hogshead staves. Both the latter acts were limited to five years.

An act of March 22, 1743, which declared the act of June 21, 1710, deficient in that it did not provide for the measurement of lumber at the place where it was received but only at the place whence it was shipped, made provision for the election at annual town meetings of a surveyor in every town where lumber was rafted off or bought. This law contained detailed directions and specifications for the inspection of shingles, hoops, staves, lumber, and the like. It was limited to expire on June 10, 1747, but was followed by other acts which revived and supplemented its provisions.

UNDER THE CONFEDERATION

The successful close of the Revolution gave new life to trade, and by an act of July 11, 1783, Massachusetts attempted to insure the building of a substantial commerce in timber products with the outside world. This required the election of surveyors in every town at the annual meetings, prescribed specifications for various timber products, provided for fees to surveyors and for certificates of inspection, imposed penalties for evasion, and repealed all former inspection acts. A supplemental act of March 16, 1784, extended the restrictions of the act of July 11, 1783, to all ports not within the State of Massachusetts, imposed additional penalties on the master or owner of any vessel who should attempt to evade the law, and declared that fully seasoned boards $\frac{7}{8}$ inch thick should be considered merchantable. This was during the period of rivalry and retaliation between the confederated States as to trade, and it is probable that the purposes of the act of July 11, 1783, had been evaded by the exportation of timber products to foreign countries through the ports of other States.

IN NEW HAMPSHIRE

On October 4, 1683, it was ordered in New Hampshire that thenceforth no pine boards should be accounted merchantable or delivered in payment unless they were a full inch in thickness and square-edged; and that if any boards were exported which did not comply with these requirements, such allowance should be made to the buyer or receiver as should be adjudged reasonable by a sworn surveyor appointed for that purpose. The preamble to this enactment indicates that it was directed largely toward the maintenance of a lumber trade with the West Indies,

from which place complaint had come as to the thinness and wany edges of New Hampshire lumber. An order of October 22, 1683, forbidding vessels of over one hundred tons burden of the Massachusetts or Plymouth Colonies from loading any boards or timber at New Hampshire ports, except under license from the New Hampshire Governor, aimed to protect home shipping.

On August 10, 1687, standard specifications for staves and boards were fixed and provision was made for official cullers; and in 1704 it was enacted that any one purchasing lumber should have the right to measure it in the presence of a selectman, constable, or other officer, and such as did not conform to its marks was to be forfeited. On June 21, 1785, a very complete lumber inspection act was passed. This act, which was unlimited as to duration, covered boards, shingles, clapboards, hoops, staves, heading, and shooks, and repealed all previous acts.

IN CONNECTICUT

THE SETTLEMENTS ON THE CONNECTICUT RIVER

An order of September 10, 1640, passed by the General Court at Hartford, Connecticut, forbade the exportation of pipestaves to foreign markets unless they were first viewed by a committee appointed by the Court and approved both as to quality of timber and as to size; and an order of September 9, 1641, restricting the felling and exportation of timber, fixed a standard size for pipestaves and provided for inspection.

UNITED CONNECTICUT UNDER THE CHARTER OF 1662

A Connecticut act of August 10, 1667, provided for inspection of timber products in every seaport town by sworn officials who were empowered "to cast by all such staves as they judge not to be merchantable either in respect of wormholes or want of assize." All pine, spruce, or cedar boards offered for exportation must be either one full inch or one-half inch thick.

An act of May 13, 1714, which declared one of its objects to be the prevention of the destruction of timber, but which in reality appears to have aimed chiefly at a discrimination in favor of British and Connecticut shipping interests employed in transporting goods to the West India Islands, imposed a duty on all pipe, barrel, and hogshead staves shipped from Connecticut to Massachusetts Bay, New York, the New Jerseys, Rhode Island, or New Hampshire. On May 12, 1715, a duty was laid on ship timber, plank, and boards exported to any of the colonies named in the act of May 13, 1714. The main object of this law appears to have been encouragement to Connecticut shipbuilding. A similar act passed

in May, 1747, levied export duties on staves, heading, ship timber, plank, boards, and bark destined to any of the colonies named in the act of 1714 except the New Jerseys. This act appears to have remained in force until 1786, when its provisions were included in the revised laws published in that year. The revised laws of 1786 also contained full provisions for the inspection of timber products offered for export.

IN RHODE ISLAND

A Rhode Island act of 1731 provided that in each town where boards, planks, shingles, clapboards, and slit work were usually imported or exported, there should be two or more surveyors elected annually at town meetings. The surveyors were required to give due consideration to drying and shrinking, and to make reasonable allowance for rots, splits, and wains. The sizes of shingles and the fees to be allowed were specified.

IN NEW YORK

No legislative control of timber inspection was exercised in New York until March 1, 1788. Under the law then enacted, the Governor and Council were to appoint an inspector for the city and county of New York, who was to appoint deputies for Albany, Hudson, Kinderhook, and other places where necessary. Sizes and quality were fixed for boards and shingles, and the inspector was required to mark his initials or his full surname, and the quantity, on each piece or bundle inspected. The inspection of staves was provided for in an act of March 7, 1788.

IN NEW JERSEY

A New Jersey law of October 2, 1694, required that before any timber, planks, boards, oak bolts, staves, heading, hoops, or hop poles were loaded in any port of that province, the master of the vessel must have a permit from the customhouse at Perth-Amboy and must have given a well-secured bond, in the sum of one hundred pounds penalty, guaranteeing that the goods would be unloaded only in the Kingdom of England, the West Indies, or one of the Summer, or Wine, Islands. Firewood and cedar shingles were specifically excepted from the restrictions of the act. Chapter 12 of the laws of the same session required the Governor to appoint an official in every town to enforce the act.

A timber trespass act of March 11, 1714, imposed duties on pipe or hogshead staves shipped to any of the British colonies on the American continent, but the duty on hogshead staves was removed on January 25, 1717. An act of December 2, 1743, imposed duties on all logs or timber products, except firewood, exported from eastern New Jersey to any of the colonies on the American continent. The penalties for violation

were very severe. The portion of this act forbidding the exportation of timber from Essex County was repealed on February 18, 1748, but the export duties were retained until the Revolution.

On September 26, 1772, inspection of timber products of all classes was provided for. Under this act, which became effective on January 1, 1773, and was limited to seven years, lumber shipped to neighboring colonies was not required to be inspected, nor was that shipped to foreign markets, if neither the buyer nor the seller required inspection.

IN PENNSYLVANIA

The first Assembly of Pennsylvania adopted on March 13, 1683, a resolution in regard to pipestaves, and section 5 of chapter 80 of the laws of 1700 fixed specifications for barrel and hogshead staves.

On April 21, 1759, the General Assembly of Pennsylvania undertook to prevent the exportation of unmerchantable staves, heading, boards, and timber by establishing specifications and providing for inspection along substantially the same lines as obtained in the New England colonies. Supplementary and amendatory acts were passed in 1761 and in 1767. The act of 1759 as thus amended appears to have remained the law until September 29, 1789.

IN VIRGINIA

In a letter of March 28, 1628, to the King, the General Assembly of Virginia advised him that pipestaves, barrel boards, and clapboards could be procured in great abundance, but that the freight was too high to make it an object to export them.

Not until more than a century later was the necessity of timber inspection recognized by the Virginia Legislature. In 1752 the dimensions and quality of staves, heading, and shingles intended for exportation to Madeira or the West Indies were fixed by a law which was limited in operation to a period of two years.

In 1786 lumber inspection was provided for the counties of Norfolk and Princess Anne and the borough of Norfolk; and on December 13, 1787, the provisions of the act of 1786 were extended to all counties and corporations of the commonwealth.

IN NORTH CAROLINA

An act of the Assembly, begun at Newbern, North Carolina, on December 5, 1770, regulated in exceptional detail the exportation of flaxseed, pork, beef, rice, flour, butter, tar, pitch, turpentine, staves, heading, shingles, lumber, tanned leather, and deerskins. Inspectors were to be appointed by justices of inferior courts in each county, to be sworn and

to give bonds. Section 27 of the act read: "Provided, nevertheless, That no Staves, Heading, Shingles, Boards, Plank, square Timber, or Deer-Skins shall be inspected, unless required"; and section 28 provided that if "dispute arose between seller and purchaser of any Boards, Plank, or other Lumber intended for the English market, the Inspector shall inspect the same, agreeable to the English Act of Parliament, if called on for this purpose." So important was the office considered that inspectors were ineligible to membership in the colonial legislature. The operation of this act was limited to ten years. After its expiration, however, the need of such a law was felt, and chapter 26 of the laws of 1784 made complete provision for the inspection of timber products offered for exportation.

IN SOUTH CAROLINA

On March 25, 1738, the Provincial Legislature passed a general act to prevent frauds in the selling of various staples, including shingles and firewood. This was followed on June 17, 1746, by a very comprehensive act on the same subject. The latter act, which was limited to three years, was allowed to lapse, but on March 12, 1783, its provisions were revived and were continued without limitation as to time of operation.

BRITISH LEGISLATION DIRECTED TOWARD THE CONTROL OF FOREST INDUSTRIES IN THE COLONIES

Within two decades after the founding of the first permanent British colony in North America, the Crown manifested an interest in the production of naval stores in the New World; and in a letter dated March 28, 1628, the General Assembly at Jamestown, Virginia, advised the King that, although there were great possibilities for the production of pitch and tar in the new country, the industry could not be profitably undertaken at that time.

On November 15, 1644, the General Court at Hartford, Connecticut, granted to two men the privilege of making tar in the colony under certain restrictions. On October 21, 1653, complaint was made to the Court of the inconveniences which had been suffered by some of the inhabitants of Windsor because of the burning of tar near the town. In 1663 John Griffin was granted two hundred acres of land for making it appear that he was the first to make pitch or tar in Connecticut.

An act of June, 1661, in the Plymouth Colony, fixed an export duty of six pence per barrel on tar made within the lands of any township, and twelve pence per barrel for any tar gathered on the "Countryes Comons," with a penalty of four shillings a barrel for evasion of the act. An order of 1668 forbidding the making of tar in Plymouth Colony was repealed on June 6, 1669; and one of 1670 providing for the granting of a monopoly for the purchase of all tar made in the colony during a period of two years, to any one who should agree to pay eight shillings a barrel and twelve shillings for each half hogshead, was repealed on June 9, 1671.

An act of June 8, 1671, in the Massachusetts Bay Colony, granted to a company a ten-years monopoly of the right to make for sale "pitch, rozin, turpentine, oyle of turpentine or masticke of the pine or cedar trees of this jurisdiction." The company was required to pay six pence per hundredweight for pitch and rosin made from timber on the commons.

In furtherance of a policy of increasing the production of naval stores, between 1664 and 1669 the duties on pitch and tar produced in Virginia and Maryland and imported into England were remitted.

The several charters and grants of lands in the New World issued to companies and individuals by James I, Charles I, and Charles II, of England, each included a full title to all trees found growing thereon, and a thriving foreign trade in shipbuilding materials and other timber products ultimately developed in the Massachusetts Bay Colony (to which Charles I granted a charter in 1629) and in the other New England colonies.

Under the beneficent guidance of Oliver Cromwell a new spirit of

maritime enterprise developed in the British nation in the decade beginning with 1650. Viewing with jealous eyes the trade expansion of the Dutch Netherlands, the English Parliament, in 1651, passed a Navigation Act which permitted the importation and exportation of goods into or from England or her colonies in English ships only, except in ships of the country from which the goods came or to which they went. This legislation probably contributed in part to the building up of a national merchant marine which was vigorously supported by an effective navy. However, merchant vessels of the Dutch and other nations continued to hold a large part of the commerce of the English colonies in North America with the West Indies and with the Continent of Europe.

Accordingly, in the first year of the Restoration, Parliament drew the line closer by enacting that from and after December 1, 1660, no goods should be imported into or exported from any of the British colonies in America except in vessels which belonged to Great Britain or to the said British colonies and of which the master and at least three-fourths of the mariners were English. Three years later a supplementary act required that after March 20, 1664, all goods destined for the English colonies in America must be laden and shipped in England, Wales, or Berwick upon Tweed, and in English vessels. This was followed by other restrictive acts, such as that which required the governors of colonies to report each year the number of ships laden out of the territory under their jurisdiction, and that of 1672 requiring that goods imported into England in colonial vessels must pay duty and that ships loading in any of His Majesty's plantations after September 1, 1673, must give bond to bring the cargo to England, Wales, or the town of Berwick upon Tweed.

With the expansion of the navy and the merchant marine of Great Britain during the Commonwealth and the early years of the Restoration, came a demand for shipbuilding materials which the European sources of supply could meet only at an increased price. Furthermore, a reliance on foreign sources for the commodities most essential to naval supremacy was a direct invitation to disaster. The accession of William of Orange to the British throne in 1688, after the depressive reigns of Charles II and James II, marked the rise of a new national hope and ambition in England. In 1684, by direction of James II, the charter of the Massachusetts Bay Colony had been vacated on a writ of *quo warranto*.

On October 7, 1691, William and Mary consolidated into a single royal province "the territories and colonies commonly called or known by the names of the Colony of the Massachusetts Bay and Colony of New Plymouth, the province of Maine, the territory called Acadia or Nova Scotia, and all that tract of land lying between the said territories of Nova Scotia and the said province of Maine," and issued a new charter

for the combined colonies under the title *The Province of Massachusetts Bay in New England.*

Although the charter of 1691 granted to the new province much of the freedom enjoyed by the Massachusetts Bay Colony under the charter of 1629, it contained one important reservation. This reservation clause declared that for the better providing and furnishing of masts for the royal navy, the grantors reserved to themselves, their heirs, and successors, all trees of the diameter of twenty-four inches and upward twelve inches from the ground, growing on any land within the province not theretofore granted to a private person. The reservation further forbade any one to cut or destroy such trees without a royal license first obtained, under penalty of one hundred pounds sterling. When one reflects that this charter granted to the inhabitants of the province four-fifths of all gold, silver, or other minerals in the lands, one begins to realize the significance of this reservation of timber.

Notwithstanding the reservation of pine trees in the charter of 1691, and the restrictions of the navigation acts, the cutting of pine and its exportation continued, in response to a strong demand for timber products from foreign nations as well as England; and when it became increasingly difficult to obtain shipbuilding material of first quality at the ports of New England, the British Crown took active steps to prevent the unnecessary destruction of trees suitable for masts.

The pressure brought to bear on the colonies by the Crown is shown in the order of the Governor and Council of New Hampshire in 1683, forbidding vessels of Massachusetts, evading the navigation acts, from loading at New Hampshire ports; in the New Jersey act of 1694, requiring the masters of vessels loading at ports of that province to give bond for the transportation of their cargoes to England, the West Indies, or the Summer, or Wine, Islands; and in a Massachusetts act of 1694–95, which declared that the King had signified his desire that a trial be made of producing naval stores in that province, and forbade any one to transport any pitch, tar, rosin, plank, or ship timber out of the province without special license from the Governor and Council

In 1696 King William III created a commission known as the Lords of Trade, to whom was assigned the duty of improving conditions in the British plantations in America. This commission undertook to develop the naval store industry in the colonies, and Lord Bellomont, who was sent to America as Governor of Massachusetts Bay, New York, and New Hampshire, exhibited a special interest in the project from his arrival in New York on April 2, 1698, until his death in the same city on March 5, 1701.

The rising prices of naval stores in Europe, together with the realization

of national needs which came in the conflicts of King William III with Louis XIV of France in the last decade of the seventeenth century, were accentuated when war between England and France began again in 1702 after a peace of only five years. This war, known as the War of the Spanish Succession, involved all of western Europe and forced upon British statesmen a consideration of every plausible means of increasing the naval independence of the nation.

With a view to establishing a permanent source of naval stores within its own dominions, the British Parliament in 1704 passed an act which placed bounties on tar, pitch, rosin, turpentine, hemp, masts, yards, and bowsprits imported from the American colonies into Great Britain. For the preservation of trees fit for the production of naval stores, this act imposed a fine of five pounds for the offense of cutting or destroying a pitch pine tree or a tar tree, under twelve inches in diameter three feet from the ground, not within a fence or an actual inclosure, within the colonies of New Hampshire, Massachusetts Bay, Rhode Island, Connecticut, New York, and New Jersey; and fixed a fine of ten pounds for the offense of wittingly or willingly firing any woods or forest in which there were trees prepared for the making of pitch or tar, without first giving notice to the person who had prepared the trees for the making of pitch or tar, in any of the said colonies. The act became effective on January 1, 1705, and was limited to nine years.

In order to insure a proper execution of this act, John Bridger, who had been engaged in the development of the naval store industry as a government agent since 1698, was commissioned Surveyor General of the Woods, and was required to instruct the inhabitants in the making of pitch and tar and other products, and to mark with the broad arrow of the British navy all trees that were to be reserved for the Crown and to keep a register of them. Bridger encountered much opposition from the colonists, who evidently considered the restrictions imposed by Parliament to be inimical to their own interests. The differences between the representative of the Crown and those who desired to exploit the forests for private gain were especially pronounced in New Hampshire, and an act passed in this royal province in 1708 imposed a penalty of one hundred pounds for every white pine or mast tree twenty-four inches or upward in diameter twelve inches from the ground, not private property, which should be cut or destroyed without royal license. The same penalty was prescribed for the unauthorized marking of any tree with the broad arrow.

Section 30 of a general fiscal act of 1709 declared that the premiums allowed by the act of 1704 for the importation of naval stores from the plantations in America were defective, and authorized Queen Anne to

expend ten thousand pounds for the subsistence and employment of persons and the purchase of materials, with a view to effecting the purposes of the earlier act.

In an act of 1710 the British Parliament referred to the vast quantities of masts and timber available near the shore in New England, New York, and New Jersey, and declared that after September 24, 1711, no person within New England, New York, or New Jersey should cut or destroy any white pine tree fit for masts that was twenty-four inches or upward in diameter twelve inches from the ground, and was not private property, under penalty of one hundred pounds. A penalty of five pounds was fixed for the offense of unlawfully marking a pine tree, in any of the colonies named, with the broad arrow of the navy. It appears from the language of the act that unscrupulous persons had been using the arrow in an unauthorized manner, to deter others from cutting trees on common lands and thus gain advantage to themselves.

In 1713 the act of 1704 was continued for a period of eleven years.

The influence of the royal authority on the legislative acts of the colonies is illustrated by a Massachusetts act passed on June 21, 1715, imposing a penalty of twenty shillings for each tree cut, barked, or boxed for the making of turpentine on any lands of the province, proprietors, townships, or particular persons, and providing for the forfeiture of all turpentine made; by a New Hampshire act of 1719, imposing a penalty of five pounds for the cutting of more than one box in a tree for the purpose of making turpentine, unless the trees were private property; and by an entry in the legislative records of New Jersey for November, 1719, making reference to the provisions of sections 16 and 17 of a parliamentary act of 1718, which forbade the payment of premiums except when the naval stores were of good quality, and prescribed an approved method of manufacture.

Section 2 of an act of 1721 sought to encourage the importation of lumber and all manner of timber products into Great Britain directly from the American colonies in British shipping, by removing all duties on such products thus imported for a period of twenty-one years from and after June 24, 1722. The act excepted masts, yards, and bowsprits, as to which provision had been made in an earlier act. Sections 3 and 4 provided for premiums on pitch, tar, and other products along the same lines as the act of 1704 and that of 1718; section 5 imposed new penalties for the offense of cutting or destroying trees fit for masts, not growing within the limits of any township, without the royal license; and section 6 repealed the part of the act of 1710 which fixed a penalty of one hundred pounds for the cutting of a white pine mast tree twenty-four inches or upward in diameter. The new penalties for cutting white pine

mast trees or drawing them away, as established in section 5, were five pounds for trees twelve inches and under in diameter three feet from the ground, ten pounds for trees from twelve to eighteen inches in diameter, twenty pounds for trees from eighteen to twenty-four inches, and fifty pounds for trees twenty-four inches and upward. These penalties were applicable in Nova Scotia, as well as in all the colonies of New England, and in New York and New Jersey.

The opposition of the colonies to the navigation acts and the acts placing restrictions on the cutting of pine was neither appeased by the free trade provisions nor subdued by the penalties of the act of 1721, and the matter again claimed the attention of the British Parliament. An act of 1729 recited the prohibition against the cutting of white pine trees not growing within any township, contained in the act of 1721, declared that the said act had been evaded through the laying out of large tracts into townships since its passage, and enacted that from and after September 29, 1729, no one should, without royal license, cut or destroy any white pine trees that were not private property, notwithstanding that the said trees grew within the limits of any township already laid out or to be laid out. This act extended the area covered by the act of 1721 so as to include every province or country in America which belonged to Great Britain or should thereafter be acquired.[5]

Section 2 made the penalties of section 5 of the act of 1721 applicable to the cutting of white pine trees on lands not private property in any British territory of America, and to the cutting of white pine trees twenty-four inches or upward in diameter on any lands in the province of Massachusetts Bay that were not private property at the time of the reservation made in the charter issued by King William and Queen Mary in 1691.

The premiums allowed by this act for naval stores imported into Great Britain from the American colonies were considerably lower than those allowed by the act of 1704, which had been extended in 1713 but had expired in 1725. The requirements of the act of 1718 as to the quality of naval stores were reenacted, and the special encouragement to the manufacture of tar by an approved method as set out in the act of 1721 was continued. All naval stores shipped from the colonies were to be subject to the "regulations, restrictions and limitations" of the navigation acts requiring bond for shipment to Great Britain under penalties and forfeitures, and the premiums were limited to a period of thirteen years. These premiums were continued, however, by successive acts until June 24, 1781.

The provision of the act of 1721 which admitted wood, timber, and

[5] For colonial views of act see New Jersey Archives, First Series, Vol. II, p. 176, 179–183. For enforcement, see Colonial Records of Connecticut, Vol. VII (1726–1735), p. 264; Provincial Papers of New Hampshire, Vol. IV, p. 563, 565; Vol. V, p. 11, 19, 97; Acts and Resolves, Province of Massachusetts Bay, Vol. III, p. 116, 326, 984; Vol. IV, p. 530, 974; Vol. V, p. 174.

lumber products from the colonies into Great Britain free of duty was continued by successive acts until September 29, 1778.

Although the terms of the earlier navigation acts requiring a shipment of all products of the colonies to Great Britain were evidently sufficiently broad to cover all kinds of timber or lumber products, through evasion and a loose construction of these acts the trade in such products between the colonies and foreign nations and their dependencies continued to thrive for a century following the Restoration. But there were frequent reports from the royal governors in America as to the great loss to British commerce which resulted from such foreign trade, and strong protest in England against the continuance of this trade. At last Parliament took action. Section 28 of a general duty act of 1763 enacted that from and after September 29, 1764, none of the timber products specified in the second section of the act of 1721 which had been grown, produced, or manufactured in any British colony of America were to be laden on any ship until bond was given to insure their transportation to no part of Europe except to ports of Great Britain, and section 29 required a warrant before such goods could be shipped to any other British colony or plantation.

An act of 1765 marked the adoption of a new policy. This provided for the payment of premiums on deals, plank, boards, and timber imported directly from the colonies into Great Britain in British ships. These premiums were to be paid at certain rates for a period of three years beginning on January 1, 1766, at lower rates for a second period of three years, and at still lower rates during a third period of three years. Section 22 of this act authorized the shipment of timber products from the colonies direct to Ireland, the Madeiras, the Azores, and any part of Europe south of Cape Finisterre.

An act of 1771 extended the provisions of the act of 1721 so that mahogany and every sort of unmanufactured timber product might be imported into Great Britain from any American colony, in British vessels, free of duty, and chapter 50 of the acts of the same year provided for bounties on white oak staves and heading imported into England direct from the colonies in British shipping. These two acts were doubtless intended as a relief to manufacturers in Great Britain, rather than as an encouragement to the colonies.

For a full century the colonies had chafed under the commercial repression of the navigation acts, and during three-fourths of that time the law had forbidden, under heavy penalties, the natural development of the timber industry. Smarting under the restraint of acts which they conceived to be unjust, the colonists had turned this way and that in search of avenues of escape from the offensive parliamentary enactments, and had become practiced in the art of legal evasion. The stamp

tax and the tea tax were but the last straws in a load that had weighed heavily on the patience of the colonists for years. While the bounties on naval stores beginning in 1704, and those on timber, lumber, and other wood products subsequent to January 1, 1766, as well as the freedom of such products from duty after June 24, 1772, may have seemed to Englishmen to be very favorable to the colonies, the restrictions as to cutting and the requirements that aimed at enforced shipment of all products to Great Britain were exceedingly irksome to the dependencies, and no inconsiderable proportion of the antipathy to British control that developed in America was among the manufacturers and shippers of timber products. It is doubtful whether any historian of the United States has recognized the important influence of British legislation interfering with the natural course of exploitation of American forests, in shaping the forces that led to the Revolution of 1775.

The shipment of lumber from Boston was stopped by the parliamentary act of 1774 closing that port until amends should be made to those who had suffered from the destruction of tea there in December, 1773. This act was followed by an act of 1775 placing an embargo on all commerce of the New England colonies until order should be restored therein. A later act of the same year extended this embargo to New Jersey, Pennsylvania, Maryland, Virginia, and South Carolina. A subsequent act of 1776 prohibited all trade with any of the thirteen colonies that joined in the Revolution. These war measures, of course, revoked the earlier acts remitting duties and affording bounties. The success of the Revolution ended the long struggle of the colonists against the efforts of the British Government to control the exploitation of American forests.

SPECIAL DEVELOPMENTS IN FOREST LAW DURING THE FIFTY YEARS PRECEDING THE FORMATION OF THE UNION

THE CONTROL OF SAND DUNES

On July 16, 1709, the Massachusetts Court, in compliance with the request of the inhabitants of a part of the neck of land that acts as a breakwater for Cape Cod Harbor, incorporated the town of Truro. This settlement appears to have been established shortly before that date, and there were only about forty families in Truro at the time of the authorization of a town government. The ambitious hopes of the people of Truro were doomed to speedy and bitter disappointment. The cutting of timber and firewood, and the grazing of stock on the commons along the shore, soon destroyed the balance of the forces of nature which had hitherto been established at the meeting line of the land and the sea. The dire consequences of the thoughtless acts of the settlers are revealed in the language of an act of the General Court passed on January 10, 1739, thirty years after the act of incorporation. The preamble to this act declared that because of the eating of the beach grass by cattle and horses along the shore of Eastern Harbor Meadows in the town of Truro, the sand was being driven, in storms and high winds, from the beach upon the meadows; that a great part of the meadowland was already buried and useless for grass, and that the whole was likely to be covered with sand if the drifting were not prevented in time. The act prescribed a penalty of forty shillings a head for neat cattle, horses, or mares turned at large to feed "between said meadows and Provincetown bounds." This act was limited to five years from the time of publication, but the evil was not easily undone and a similar act was passed on April 5, 1745, for a limited period. The later act was extended, by successive acts of 1751, 1755, 1760, 1770, 1776, 1779, and 1785, until November 1, 1797. Thus was the experience of the inhabitants of the western coast of France duplicated on the eastern shore of New England, and thus did Americans begin the attempt to control by legislation the baleful effects of drifting sand.

The act regarding the beaches of Truro was followed by one of December 28, 1739, directed toward the protection from drifting sand of the meadows of Plumb Island, in Ipswich Bay. The preamble to this act shows that the effects of forest fires, as well as of the cutting of trees and the feeding of animals, were recognized as a contributing cause to the encroachments of drifting sand. This act forbade the running at large on Plumb Island of any animals, under penalty of twenty shillings each for cattle, horses, or mares, and five shillings each for sheep or swine; imposed a penalty of ten pounds for firing the beach grass, bushes, or

shrubs; and provided a forfeit of ten shillings for each bush, shrub, or tree under six inches in diameter cut from the said beach or marsh. This act was limited to five years, but was repeatedly extended during the colonial and confederation period until November 1, 1797.

On January 9, 1741, a penalty of forty shillings per head was imposed for cattle, horses, or mares not owned by an inhabitant, found feeding on the lands of Provincetown. So serious had the drifting of sand become even then that this act appears to have had chiefly in view the protection of Cape Cod harbor. The waste was so complete that the exodus of inhabitants rendered it necessary to pass a special enabling act on November 11, 1743, to authorize the few remaining inhabitants to conduct local affairs as if they had sufficient population for a town, and by an act of April 5, 1745, the Governor and Council were authorized to draw on the public treasury of the colony for the amount necessary to maintain a pound for animals taken up in Provincetown in the enforcement of the law.

The act of January 9, 1741, also limited strictly the amount of stock which the inhabitants of Provincetown might themselves keep, and imposed penalties for the cutting of trees or bushes. This act was revived and continued by various successive acts until November 1, 1797.

Similar acts were passed for the protection of nearly a dozen other meadows and beaches during the colonial period, and several laws of this character were enacted during the confederation. An act of March 7, 1797, after the establishment of the Union, made many of these acts perpetual.

COOPERATIVE FORESTRY

From the time of the very earliest settlements in New England there existed sequestered commons which to all practical purposes were town communal forests. The year 1744, however, marks the introduction of an entirely new idea in the use and control of a common forest. This was nothing less than the organization of a number of private owners of forest land into a sort of corporation, for the purpose of managing their contiguous lands as a single unit, with the conscious intention of growing wood crops. On March 24, 1744, the General Court of the Province of Massachusetts Bay authorized any five proprietors of the lands embraced within Chebacco Woods, in the town of Ipswich, to apply to a justice of the peace, setting forth in writing their purpose to establish a common woods. The justice was then to make out warrants authorizing a call for a meeting of all proprietors, and if at this meeting two-thirds of all the proprietors, "reckoned by interest," should see meet, they might by a vote embody themselves into a society in which all the proprietors owning land within the proposed limits should be

included. The proprietors were to control and manage this wood like the proprietors of other common fields and woods. Any party thinking himself aggrieved by the action taken at the meeting could apply for relief, and a court of general session would hear the cause and give a judgment that should be binding. The act was unlimited as to the time that the society should continue.

On January 9, 1755, the Massachusetts Court authorized the proprietors of woodlands lying contiguous in the towns of Ipswich and Wenham, commonly known as "Wenham Great Swamp," to form an association like that authorized for Chebacco Woods. The object of this act is disclosed by the title, which read: "An Act for the securing of the growth and increase of a certain parcel of wood and timber in the towns of Ipswich and Wenham, in the county of Essex." The operation of this act was at first limited to ten years, but it was extended by successive acts until November 1, 1797. On March 7, 1797, this act, and another of March 6, 1793, covering other lands in the towns of Ipswich, Wenham, Beverly, and Manchester, were made perpetual.

USE OF RIVERS AS HIGHWAYS FOR LOGS, RAFTS, AND OTHER TIMBER

At a session of the General Assembly of Connecticut begun on May 14, 1752, an act was passed "to prevent secret Trespasses in taking up and disposing of Saw Mill Logs and other Timber, Shingles and Staves, floating or floated down the Connecticut River." Any person taking up such logs or timber "fairly marked," or shingles and staves which were bundled, was required, within one week, to "enter the same with the kind, bigness, length, and marks on the logs and timber, the number of bundles and the kind of the shingles and staves, and by whom taken up, and the place where they lye, with such clerk or clerks where strays and lost goods are by law to be entered, and shall let such logs, timber, shingles, and staves lye without disposing thereof, or any ways defacing the marks thereon, full six months after the first entering the same; on penalty of forfeiting and paying to the owner or owners.................... the sum of ten shillings for every log or other stick of timber not exceeding thirty feet in length, and double the value of such shingles or staves and ten pounds for every log or other stick of timber which exceeds thirty feet in length." The person taking up the logs or timber was entitled to a fee of one shilling and two pence for every log or stick not over thirty feet long, and the same for a bundle of shingles or staves, and four shillings and two pence for every log or stick over thirty feet long; three pence of the reward for each log or stick to be given to the clerk for the recording. An owner of timber thus taken up and entered who took it away without paying the required fees, forfeited ten shillings for every log or stick

not over thirty feet long, the value of the shingles or staves, and five pounds for every log or stick over thirty feet long. If no owner appeared in six months, the person taking up the timber could convert it to his own use.

In October, 1771, a similar law was enacted to prevent the theft of timber products from the Windsor Ferry River, and the General Assembly of Connecticut held at New Haven in October, 1785, passed an act providing that any one who should stop, take up, or interrupt any mast, yard, or spar, over forty feet in length, floating down the Connecticut River, in Connecticut and above Middletown, without authority from the owner, should be liable for double damages to the owner.

An enactment of April 28, 1781, in Massachusetts, provided that if timber were left by spring floods, on any improved land adjoining the Connecticut River, the owner of the land was to cause to be recorded in the *Book of Records* of the town the marks and lengths of the said timber and the place where it was left. He was then entitled to one shilling as reasonable damages for each stick of timber so left, two pence of which amount was to go to the town clerk as a fee for recording. A proviso saved to the owner of the timber the right to cause it to be removed by the 15th day of May succeeding the time when it was left, without liability for damages. However, if the owner of the timber failed to have it removed within twelve months from the date of the recording with the town clerk, the timber was to be adjudged the property of the owner of the land. By the terms of this act all islands within the Connecticut River were excepted from its provisions, but an additional act of July 7, 1786, extended its provisions to "Smead's Island" in the Connecticut River.

New Jersey early recognized that it was necessary for the colonies to boldly break away from the view of the English common law, that only tidal rivers were navigable, and the important part which the development of her timber resources played in this movement appears in the words of an act passed by the General Assembly on August 20, 1755, as follows:

> WHEREAS, The Transportation of Timber, Plank, Boards, Hay, and other Things to Market by Water, is a great Conveniency to the Inhabitants of this Colony, and the Preservation of those Advantages are highly worthy the Care of the Legislature, *Be it enacted*,....................That if any Person or Persons without first obtaining an Act of the General Assembly for that Purpose, shall, after the Publication of this act, erect any Dam, Bank, Sluice or other Thing which shall obstruct or prevent the free and uninterrupted Navigation of any River, Creek, or Stream of Water within this Colony, which is used for the Navigation of Boats or Flats, or for the transporting of Hay, Plank, Boards, or Timber, or shall fall any Trees across such Creek, or throw Brush or other Filth in any Part thereof, between the Mouth thereof and the uppermost Place thereon, now or of late used as a Landing, he, she, or they so offending shall severally forfeit the Sum of Five Pounds, Proclamation Money.

On March 9, 1771, the Pennsylvania Legislature declared the Delaware and Lehigh Rivers and certain parts of the Neshaminey and Lechawaxin

Creeks to be "common highways....................for vessels, boats, small craft and rafts of any kind whatsoever," and in another act of the same date made certain parts of the Susquehanna and Juniata Rivers and several smaller streams public highways for the same vessels. On April 13, 1782, the Monongahela and Youghiogheny Rivers were made highways "so far up as they or either of them have been or can be made navigable for rafts, boats and canoes, and within the bounds and limits of this State." The economic necessity that led to the overthrow by legislation of the common-law test of navigability is strikingly disclosed in the language of a Pennsylvania act of March 31, 1785, which read:

> And Whereas, The extensive countries which are watered by the river Susquehanna, and the numerous branches thereof, are stocked with immense quantities of oak, pine and other trees, suitable for staves, heading, scantling, boards, planks, timbers for ship-building, masts, yards and bowsprits, from which great profit and advantage might arise to the owners thereof, if the same could be conducted in rafts and otherwise, down the said river, to the waters of Chesapeak, which trees must otherwise perish on the lands whereon they grew: For remedy whereof,
>
> Sec. IV. *Be it enacted* by the authority, aforesaid, That the river Susquehanna shall be deemed and taken to be a public highway, in all parts thereof within this state, from the division line of the state of Maryland and this state upwards to the town of Northumberland, in the county of Northumberland, and thence, by and along each of the two great branches of the same river, which meet at the said town, in and throughout the whole length and breadth of the same river.

These acts marked the beginning of a policy which was extended to numerous rivers in Pennsylvania, New York, and New England by acts passed subsequent to the formation of the national Union, and eventually adopted in Central, Western, and Southern States.

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Department of Plant Pathology

THE LEAF BLOTCH OF HORSE-CHESTNUT

V. B. STEWART

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LEAF BLOTCH OF HORSE-CHESTNUT

THE LEAF BLOTCH DISEASE OF HORSE-CHESTNUT

V. B. Stewart

The horse-chestnut (*Æsculus hippocastanum*) is common throughout the State of New York. In public parks and private plantings the large, magnificent trees, with their deep green foliage, are particularly attractive. Ordinarily they are not considered desirable for street trees, however, owing to the excessive water supply that they demand; but in certain localities they have been used extensively for street planting, and in many cities the species is very prevalent.

There is some objection to the horse-chestnut because of the frequent yellowing and dying of the foliage during the summer. On trees that have received but little attention, the foliage is in many cases so dense that the inner leaves die and fall to the ground for lack of sunshine. It is believed, however, that a large proportion of the yellowing and subsequent death of the foliage may be attributed to leaf blotch, which is the most important disease affecting the horse-chestnut (*Æsculus hippocastanum*) and the Ohio buckeye (*Æ. glabra*).

Leaf blotch is known in America and in Europe, apparently occurring, to some extent at least, wherever the horse-chestnut or allied species are found. It is not observed so commonly in northern Europe as in southern Europe, and apparently is never so destructive in these regions as in America. In the eastern part of the United States, where the horse-chestnut has a wide distribution, the disease is frequently observed, and in many cases a large proportion of the foliage on mature trees is affected.

In nursery plantings leaf blotch is particularly destructive. In many cases the seedlings are completely defoliated by midsummer, and as a consequence their growth is greatly retarded. When the disease has once become established in a block of young nursery trees it usually causes considerable damage each year. The affected trees develop more slowly than they would normally, and a longer period of time is therefore required for them to attain a marketable size. Several plantings from seed have been observed which had made practically no increase in size for three seasons, due to the abundant occurrence of the leaf blotch disease each year.

Not only does premature defoliation check the growth of the young trees, but apparently the trees affected are less able to withstand the adverse conditions of the subsequent winter months. An injury and dying back of the twigs and branches has been observed on trees that were badly diseased the preceding summer.

The plantings of horse-chestnut in the nurseries of the State are relatively large, owing to the persistent annual demand for this stock. As a rule, however, nurserymen have not been successful in propagating the trees from seed because of the severe injury to the foliage caused by leaf blotch. This failure has resulted in annual importations of horse-chestnut trees from foreign countries. The trees obtained from Europe are three or four years old. They are planted in the nurseries of this country, where they are allowed to grow for one or two years longer before they are placed on the market. This method naturally involves considerable expense, requiring the nurserymen to charge a higher price for their stock than for trees successfully grown from seed in this country. Without question horse-chestnut trees protected from the leaf blotch disease can be propagated from seed at a much lower cost than that paid for imported stock.

SYMPTOMS

The leaves, and occasionally the petioles, are affected. The writer has observed lesions also on immature fruits, which were undoubtedly another type of the leaf blotch disease.

The first indication of the disease on the foliage is a slight discoloration. As the lesion increases in size it becomes more or less irregular in outline and the newly invaded tissues appear water-soaked. Gradually the central part of the lesion becomes from dark red to brown in color, while the margin shows a yellowish discoloration blending into the green of the healthy tissue. The discolored area finally becomes dried and dies. The spots may be small, or they may involve a large part of the leaf surface and thus cause the dead area to curl (see frontispiece). Minute black specks may generally be seen, scattered separately over the lesion, and in some cases these appear before the tissue is completely dried out. In many cases these specks are crowded together in a definite area, which may be slightly lighter in color than the remainder of the affected tissue.

The lesions on the petioles appear in the form of small reddish brown spots, which are usually somewhat longer than wide and extend up and down the petiole. The effects of the disease on the petiole are never very serious.

The spots on the fruit are similar to those on the petioles, but there is no decay of the fruit tissue.

The striking symptom of the leaf blotch disease, however, is the dark red or brown color of the lesions, which often involve large areas or even the entire leaf. When the disease is very prevalent, especially in nursery plantings, the foliage appears as if it had been burned over by fire.

CAUSE OF THE DISEASE

Leaf blotch is caused by a fungous pathogene, *Guignardia Æsculi* (Peck) Stewart. This parasite obtains its food and nourishment by means of minute vegetative, root-like strands, called mycelium, which penetrate the leaves of the horse-chestnut and kill the tissues invaded.

LIFE HISTORY

With the presence of the fungus in the leaf, the mycelium extends in all directions and kills the surrounding tissues, producing the characteristic leaf blotch lesions. Soon gnarls of the mycelial threads appear at various points near the upper surface of the leaf, and these result in the formation of fruiting bodies of the fungus. These fruiting bodies are known as pycnidia (Fig. 85), and are the characteristic minute specks already mentioned as appearing on the upper surface of the affected area.

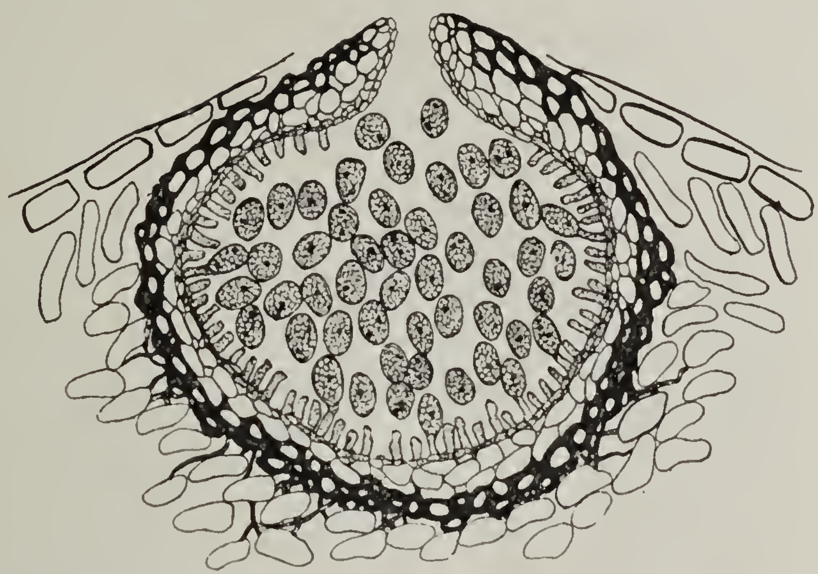

Fig. 85. cross section of a horse-chestnut leaf through a pycnidium of the fungus (much magnified)

The spores are shown inside the pycnidium. They escape through the opening in the top

Within the pycnidium are borne a large number of spores, which are extruded from the opening in the top of the pycnidium. The spores, being very minute, are easily carried to other leaves by wind and rain, and are thus disseminated to a considerable distance. Falling on a leaf, the spore germinates, if moisture is present, by sending out a slender germ tube (Fig. 86, A), which grows into the tissue of the leaf and develops a mycelium with many branches, causing a disorganization and killing of the tissue in the affected area. When a number of spores infect the same leaf, a large part or all of the tissue becomes affected and the leaf is no longer able to function in the manufacture of food for the tree.

Fig. 86. spore forms of the leaf blotch fungus

A, pycnospores, some of which have germinated; B, ascus, containing eight ascospores; C, ascospores, some of which have germinated

As the season advances the disease becomes more prevalent with each period of wet weather, and, on nursery trees especially, a large part of the foliage may be killed by midsummer. The fungus lives over winter in the old diseased leaves that fall to the ground. During the winter there are formed on these fallen leaves special fruiting bodies, known as perithecia (Fig. 87), which become mature about the time when the trees develop the first new leaves in the spring. Within the perithecium are numerous sac-like bodies, known as asci (Fig. 86, B), containing spores which escape through the opening in the top of the perithecium. These ascospores (Fig. 86, C), being very minute, are carried by the wind or by spattering drops of rain to the new foliage, where they produce the first infections of the year. From ten to fifteen days later the characteristic leaf blotch lesions begin to appear, and soon pycnidia are formed which are a source of further distribution of the fungus.

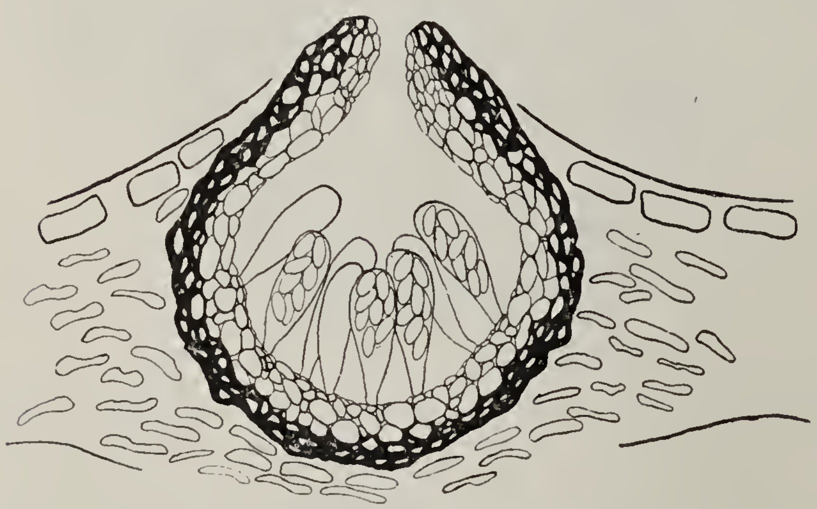

FIG. 87. CROSS SECTION OF A HORSE-CHESTNUT LEAF THROUGH A PERITHECIUM (MUCH MAGNIFIED)

The drawing shows the sac-like bodies (asci) with ascospores. In early spring the spores escape through the opening in the top of the perithecium

Small trees in the nursery, on which the foliage is near the ground, often show numerous spots early in the spring. This is due to the fact that a large proportion of the spores of the winter stage (perithecia) are able to reach the newly developed leaves and produce infections during periods of damp, cloudy weather. In mature trees the chances that the spores may reach the newly developed foliage from the perithecia in old leaves on the ground are usually limited, but at least a few leaves generally become infected in this manner, and the pycnidia with spores, which develop in the lesions, are the source of new infections whenever conditions are favorable. When there is but little rainfall throughout the summer, very few spores find suitable conditions for germination and thus but little of the foliage is attacked. For this reason the disease may be more prevalent in certain years than in others.

CONTROL

In determining control methods for a fungous disease it is necessary to consider the relation existing between the host and the parasite that causes the disease. In general, in the case of leaf blotch of horse-chestnut, weather conditions that influence the trees affect also, to some extent,

the activities of the fungus. Rainy periods throughout the summer favor the growth of the trees, since sufficient moisture is supplied for their development. On the other hand, wet weather also affords the necessary conditions for the pathogene. With the presence of moisture the fungus spores are able to germinate and produce infections when they fall on the leaves of the trees. For the control of the leaf blotch disease, therefore, it is necessary to check the attack before suitable conditions

FIG. 88. A HAND DUSTING MACHINE
This duster is suitable for dusting small trees

are afforded for the germination of the spores on healthy foliage. It is impossible to check the activities of the parasite in the affected leaf after the spores have germinated and the germ tubes have gained an entrance into the leaf tissue.

As previously stated, the first infections in the spring are produced by spores from the perithecia in old dead leaves on the ground. Undoubtedly much damage can be prevented by plowing under or burning the old leaves before the new foliage is developed. A large proportion

of the perithecia are thus destroyed and the source of early infections is to a considerable extent eliminated. On the other hand, this treatment is not sufficient to completely control the disease, for usually enough old leaves remain scattered about to enable the fungus to gain a foot-hold on the new leaves.

In order to forestall these attacks of the fungus and subsequent infections by spores from the pycnidia, the leaf surface must be covered with a fungicide that is poisonous to the parasite. When the spore germinates, the germ tube comes in contact with the fungicide and is

FIG. 89. A POWER DUSTING OUTFIT
This machine is suitable for dusting large trees

killed, and thus its entrance into the tissues of the leaf is prevented. The fungicide does not penetrate the leaf and kill the mycelium, and since the spores are very minute — being about $\frac{1}{2500}$ of an inch in diameter — the fungicide must be applied so that it completely covers all parts of the leaves. The applications must be made at such intervals as will afford the greatest amount of protection throughout the summer. The proper time for the first application, especially for nursery stock, is soon after the buds open in the spring. This should be followed by at least two other treatments, made at intervals of from two to three weeks. In rainy seasons it is advisable in many cases to make one or

two additional applications in order that the foliage will be thoroughly covered with the fungicide at all times.

Lime-sulfur solution (one gallon to fifty gallons of water) or bordeaux mixture may be used for controlling the disease. Considerable difficulty has been experienced, however, in the use of these spraying mixtures owing to the dense foliage of horse-chestnut trees. In the attempt to cover thoroughly all parts of the foliage, the trees are often drenched with the spray solution, and when lime-sulfur solution is used severe burning of the leaves may result.

In the summer of 1915 an experiment was made on nursery trees for the control of leaf blotch by dusting. The dust mixture used contained ninety parts of finely ground sulfur [1] and ten parts of powdered arsenate of lead.[2] This mixture proved as effective as lime-sulfur solution in controlling the disease. On trees that were not treated, practically fifty-nine per cent of the leaves were diseased; while only three per cent of the leaves on the trees that were dusted showed infections, and the trees sprayed with lime-sulfur solution 1–50 had ten per cent of the foliage diseased.

PHOTOGRAPH BY F. H. POUGH

FIG. 90. DUSTING SHADE TREES

In comparing the results on the sprayed and the dusted trees, it is believed the lime-sulfur spray was the less effective mainly because of the density of the foliage. The spray was applied with a hand sprayer which lacked sufficient power to furnish the driving spray necessary to thoroughly cover all parts of the foliage, while, on the other hand, the cloud of finely ground dust mixture floated through the trees and settled on the leaves, completely covering them and thus affording better protection.

The dust mixture was applied with a hand machine, illustrated in figure 88. This duster is very satisfactory for treating small shade

[1] The sulfur was so finely ground that at least 95 per cent would pass through a 200-mesh sieve. The method of testing sulfur is described by F. M. Blodgett in Bulletin 328 of this experiment station.

[2] The lead arsenate was added primarily for its adhesive properties. On being moistened there is a tendency for it to become somewhat gelatinous and sticky, and this increases the adhesiveness of the mixture. Lead arsenate is effective also in controlling insects that chew the foliage. In the case of horse-chestnuts, however, which are seldom attacked by insects, finely ground gypsum, a much less expensive substance, may be substituted for lead arsenate.

trees or for use in small plantings of nursery stock. For dusting on a more extensive scale a power machine, such as is illustrated in figures

PHOTOGRAPH BY F. M. BLODGETT

FIG. 91. A TRACTION DUSTING MACHINE
This duster is suitable for treating nursery stock

89 and 90, is preferable. The outfit shown has been used successfully for dusting orchard trees. The machine is operated by a gasoline engine, and the cloud of dust mixture, which is discharged from the long pipe,

PHOTOGRAPH BY F. M. BLODGETT

FIG. 92. TRACTION DUSTING MACHINE IN OPERATION

floats through the trees and completely covers all the foliage. The machine is suitable also for dusting shade or park trees.

For treating large plantings of horse-chestnut trees in the nursery, a traction duster such as is illustrated in figures 91 and 92 is desirable. The machine is especially light in weight and runs between the rows, the dust being discharged from the two pipes in the rear. One man and a horse are all that is required to operate this machine.

Although spraying is effective in controlling leaf blotch, the dust method is preferable, as there is less danger of injuring the foliage by burning; further, the dust mixture can be applied more thoroughly and with greater facility than the spraying solution. The dust mixture is somewhat more expensive than the spraying solution, but its greater cost is offset by the consequent saving in time and labor.

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AGRICULTURAL EXPERIMENT STATION OF THE
NEW YORK STATE COLLEGE OF AGRICULTURE
BEVERLY T. GALLOWAY, Director
Department of Entomology

REPORTS ON SCALE INSECTS

BY JOHN HENRY COMSTOCK

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PREFACE

Among the more important insect pests of cultivated plants, and especially of fruit trees, are those of the family Coccidae, or scale insects, of which the San José scale is an example. An appreciation of this fact led the writer of the reports republished here to make a study of the insects of this family.

The investigation was begun in the year 1879, while the writer was Entomologist of the United States Department of Agriculture, and was continued after his retirement from that position, he being then Entomologist of the Cornell University Agricultural Experiment Station. Prior to the publication of its results no general work on the scale insects of the United States had appeared, the published accounts of these insects consisting of isolated descriptions of a few species. In the reports of the results of this study a monographic treatment of the family Coccidae is presented, the previously known American species are redescribed and figured, and forty new species are described. These descriptions are accompanied by detailed figures of the microscopic characters by which the different species are distinguished and which were first elucidated in the course of this investigation.

Excepting the catalogue of the Coccidae published by Mrs. Fernald — in which, however, there are no descriptions of species — these reports remain the only general treatise on scale insects published in the United States. They are, however, unavailable to most workers in economic entomology, as they have been out of print for a long time. Many requests for them have been received by the New York State College of Agriculture, and so urgent is the demand for this fundamental treatise that it seems wise to reprint the reports.

The first of these reports appeared in the Annual Report of the Commissioner of Agriculture for the year 1880 (pages 425 to 500); the second, in the Annual Report of the Commissioner of Agriculture for the years 1881 and 1882 (pages 501 to 506); the third, in the Second Report of the Cornell University Agricultural Experiment Station, published at Ithaca in 1883 (pages 507 to 603). The pagination, and the figure numbers and their sequence, of the original reports have been retained for the benefit of those who will find references to the original works. The regular page numbers of the Cornell bulletin series are also used, however, and these are placed at the top of the page, while the original page numbers, inserted for the benefit of librarians and research workers, are placed at the bottom of the page. Each cut bears below it, in parenthesis, the consecutive figure number of the Cornell experiment station publication.

REPORTS ON SCALE INSECTS.

J. H. Comstock

REPORTS ON SCALE INSECTS

(Including descriptions of Coccidae in the collection of the United States Department of Agriculture, with notes upon the habits of those injurious to cultivated plants, and the results of experiments in their destruction)

(From Report of U. S. Commissioner of Agriculture, 1880)

INTRODUCTION

There is no group of insects which is of greater interest to horticulturists to-day than that family which includes the creatures popularly known as "scale insects" and "mealy bugs." There is hardly any shrub or tree but that is subject to their attack; and in certain localities extensive orchards have been ruined by them. The minute size of the creatures, the difficulty of destroying them, and their wonderful reproductive powers, all combine to make them the most formidable of the pests of our orchards and ornamental grounds. It is only necessary to cite the mealy bugs of greenhouses, the oyster-shell bark louse of the apple, and the various species of scale insects destructive to citrus fruits to establish this fact.

Notwithstanding the great importance of the subject, comparatively little thorough work has been done on the species of this country. This is doubtless in a great part due to the difficulties attending a careful study of even a single species of this group, and the fact that the small size and plain appearance of the insects render them unattractive to most entomologists.*

This report on scale insects is an outgrowth of the investigation of insects injurious to orange trees, which was begun last year. In the early part of that investigation I became convinced that by far the greater part of the injury done to orange trees by insects was caused by scale insects; and that I could not do a more useful work than to make an exhaustive study of that family, including not merely those that infest citrus trees, but all the species occurring in the United States. I collected many of our southern species while on a trip through the State of Florida during the months of January and February, 1880; during the following summer I spent three months in the fruit-growing sections of California and Utah, investigating the scale insects found there; and extensive collections were also made by assistants and correspondents in the eastern part of the United States. A series of experiments were made to ascertain the best method of destroying these pests, and with very satisfactory results. These experiments will be continued during the present season. Many species, including all those that infest oranges in this country, were colonized on small trees growing in pots in the breeding room of the division. In this way we have been able to follow their complete life history. In some instances the species has been observed daily through five generations.

For want of time I have been unable to prepare descriptions of all the species which we have collected. I hope, however, to be permitted at some future time to publish a more exhaustive memoir on the subject, and trust that the reader will remember that this is simply the result

* Previous to this only about thirty species have been described by American writers; and of this number more than one-half were described by Dr. Asa Fitch, the first State Entomologist of New York.

of but little more than one year's study pursued with limited means (there being no special appropriation for it) and in addition to the ordinary duties of the division of entomology.

CHARACTERS OF THE COCCIDAE

The scale insects, or bark lice, and the mealy bugs, together with other insects for which there are no popular names, comprise the family known to entomologists as the Coccidae. This is a division of the order HOMOPTERA, to which belong also the plant lice (Aphidae), the cicadas, the leaf hoppers, and certain other insects.

We will not in this place enter into a discussion of the characters of the Homoptera or of the zoological relations of the Coccidae to the other families included in that order. But referring those who are interested in these points to the textbooks on entomology (see also report of this department for 1876, pp. 24–46), we will proceed at once to a discussion of the Coccidae.

In many respects this is a very anomalous group of insects, differing greatly even from closely allied forms in appearance, habits, and metamorphoses. Not only do the members of this family appear very different from other insects, but there is a wonderful variety of forms within the family; and even the two sexes of the same species in the adult state differ as much in appearance as insects belonging to different orders.

The most obvious characters in which the Coccidae agree, and by which they may be distinguished from other insects belonging to the Homoptera, are the following: the females never possess wings; the males are winged in the adult state, but unlike other homopterous insects possess only a single pair of wings, the second pair being represented by a pair of small club-like organs called halteres, each usually furnished with a bristle, which in all the species that I have studied is hooked and fits into a pocket on the anterior wing of the same side.* (See Plate XXI.) The male in the adult state has no organs for procuring food, the mouth parts disappearing during the metamorphoses of the insect and a second pair of eyes appearing in their place.

The strange forms assumed by certain species of bark lice has led to their being mistaken for very different organisms. Thus the adult females of a species of a genus of bark lice (Kermes) common on oaks in various parts of the world have been commonly mistaken for galls. A species of this genus is represented on Plate IX, figure 1; the gall-like objects on the twig of oak are the females; the immatured males are very different in form, and are represented on the leaves. The resemblance to galls is shared somewhat by certain other genera of this family. In fact, the family is termed by the French *Gallinsectes* on account of this resemblance.

There is a remarkable species belonging to this family found in the West Indies in the furrows of the land newly turned up, which from its resemblance to a pearl is known as the ground pearl, and is frequently sent to Europe in collections of shells under that name. It is stated by Guilding, who first described this insect (Trans. Linn. Soc. Lond., 1833, T. 16, P. 1, pp. 115–119) under the name of *Margarodes formicarium,*

* The relations existing between the halteres and the anterior wings were first observed by Mrs. Comstock while making drawings for this report. She has repeatedly seen a male in the act of replacing the hook of the bristle in the pocket from which it had been removed while the insect was being mounted for examination under a microscope. Our observations, however, have been too limited to enable us to state positively what is the function of the halteres; but we believe that they aid in flight.

that it occurs in the Bahamas, and is strung into necklaces and ornamental purses by the ladies. It was believed by Guilding that the ground pearls were parasitic on the ants, in and near the nests of which they were found. I think, however, that it is more probable that the so-called pearls derive their nourishment from the roots of plants in the soil, and that they, instead of destroying ants, furnish them with food in the form of an excretion, as many other species of Coccidae are known to do.

The habit of excreting a sweet fluid, which many species possess, together with the strange forms of the insects, has also led to some strange mistakes. Thus one species which occurs on pine was at first taken for a nectar-secreting gland (Unger, Flora, 1844, p. 713).

DIVISION OF THE COCCIDAE INTO SUBFAMILIES

Owing to the great diversity of form and structure among the species belonging to this family they may be grouped into several subfamilies; and such a grouping is necessary before generalizations can be made respecting the habits and metamorphoses of the various species. Signoret in his monograph of this family divides it into four sections.* We believe that each of these sections should rank as a subfamily, and will so consider them. They are characterized as follows:

I. Diaspinae.— This subfamily includes all the species of Coccidae covered by a scale composed in part of molted skins and partly of a secretion of the insect.

Examples.— The oyster-shell bark louse of the apple (*Mytilaspis pomorum*), the red scale of the orange (*Aspidiotus aurantii*), and Glover's orange scale (*Mytilaspis Gloverii*).

II. Brachyscelinae.— This subfamily includes certain species of Coccidae which live in galls. All the described species are Australian. Consequently the subfamily will not receive further notice in this report.

III. Lecaninae.— The original characters of this subfamily as given by Signoret are as follows: Species either naked or inclosed, or simply covered with waxy calcareous or filamentary material; most of the females after impregnation taking on a different form, and, once fixed, remaining so for the rest of their lives, although while young they retain the power of moving under certain circumstances.

IV. Coccinae.— Signoret originally gave the characters of the Coccinae as follows: Females keeping the form of the body with the segments distinct until the end, and also retaining the power of motion; they are naked or covered more or less with a wavy whitish excretion, filamentary and more or less spumous.

These characters were afterwards found to be insufficient to separate the two groups as the genus Kermes which, from the study of the young larva, belongs evidently to the Coccinae, is fixed and covered with a hard horny substance, hiding the segmentation and giving it precisely the appearance of a Lecanium. Signoret therefore substituted the following characters: Lower lip 1-jointed in the Lecaninae, multiarticulate in the Coccinae; anal plates present in the Lecaninae, absent in the Coccinae; anal extremity with the Coccinae divided into two lobes, each furnished with a long bristle.

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*Annales de la Société Entomologique de France, 1869, p. 98. We have not included the section Lecanodiaspis established by Targioni-Tozzetti, as all the representatives of it which we have been able to study have been found to belong to some one of the other sections.

Examples of Lecaninae.— The black scale of California (*Lecanium oleae* Bernard), the maple-bark louse (*Pulvinaria innumerabilis* Rathvon), the lac insect (*Carteria lacca* Ker.).

Examples of Coccinae.— The mealy bugs (Dactylopius), the cochenille insect (*Coccus cacti* Linn.).

METAMORPHOSES OF THE COCCIDAE

The changes through which a scale insect passes in the course of its development are very remarkable. But as the metamorphoses and habits of each division of the family are somewhat peculiar, it is necessary to consider each subfamily by itself. We will discuss in this place only the first subfamily.

1. THE DIASPINAE.— The newly-hatched scale insect is oval in outline, much flattened, furnished with six legs, a pair of antennae, and an apparatus for sucking the juices from plants. (See Plate III, fig. 2*c*, young of *Aspidiotus ficus.*) At this stage of its existence it is very small, a mere speck, which the untrained eye could only with difficulty detect. By means of a lens, however, these minute creatures can be seen crawling in all directions over the leaves or bark of an infested tree. After wandering for a time, usually but a few hours or even less, the young scale insect settles on some part of the plant, inserts its beak, and, drawing its nourishment from the plant, begins its growth at the expense of its host. In a short time there begins to exude from the body of the larva fine threads of wax, which are cottony in appearance. The excretion of this wax continues until the insect is completely covered by it. The rate at which this excretion is produced varies greatly. Thus larvae of the red scale of Florida (*Aspidiotus ficus*) which were only one day old were found to be completely covered by the cottony mass which they had excreted, while the larvae of Glover's scale (*Mytilaspis Gloverii*) did not become entirely covered until they were six days old. Sooner or later the larva begins to excrete a pellicle, which, although very thin, is dense and firm in texture. The mass of cottony fibers either melts or is blown away, or, as in certain species of Aspidiotus, a portion remains as a white dot or ring on the center of the scale. After a period, which in several species that we have studied is about one-half of the time from the hatching of the larva to the emerging of the male, or one-third of the time from the birth of the female to the date at which she begins ovipositing, the larva sheds its skin. In some species this does not take place until after the beginning of the formation of the permanent scale, and in such cases the molted skin adheres to the inner surface of the scale, and cannot be seen while it is in its normal position on the plant. This is true of many species belonging to the genus Aspidiotus (*A. ficus, A. citri, A. perniciosus,* and others).* In these species the position of the exuviae is indicated by a nipple-like prominence, often marked by a white ring or dot, which is the remains of the cottony mass first excreted. In other species the molt takes place before the beginning of the excretion of the permanent scale. In these the larval skin is plainly visible either upon the surface of the scale, as in certain species of Aspidiotus (*A. nerii,* Plate IV, fig. 1*c*) and in Diaspis (Plate V, fig. 1*a*, 2*a*), or at one extremity, as in Mytilaspis (Plate VII, fig. 1*a*). Sometimes, however, the larval skin is covered by a delicate transparent layer, which, I think, is the melted or compacted remains of the cottony mass excreted by the young larva (Plate VII, fig. 2*a*).

* For figures of *A. ficus* and *A. citri* see Plate III.

The change which the larva undergoes at this molt is a very remarkable one, appearing to be a retrogression instead of an advancement to a more highly organized form, as is the rule in the development of animals. With the skin are shed the legs and antennae.* The young scale insect thus becomes a degraded grub-like creature with no organs of locomotion. The mouth parts remain, however, in a highly developed state and are well fitted to perform their functions. This apparatus is not the least remarkable thing in the structure of these insects. It is terminated by a thread-like organ, which is frequently much longer than the body of the insect, and is composed of four delicate hair-like bristles. By means of this organ the insect is firmly attached to the plant and draws its nourishment therefrom. From this stage the development of the sexes differs.

The second and last molt of the female takes place, in those species which we have studied most carefully, when she is about twice as old as when the first molt occurred. The change in appearance at this molt presents nothing remarkable. The second cast skin is joined to the first and with it forms a part of the scale which covers the body of the insect. Sometimes, as in the genus Fiorinia (Plate XI, fig. 7), this molted skin is very large and constitutes the greater part of the scale; but more commonly the exuviae form but a small proportion of the scale, the greater part of it being excreted subsequently to the second molt. Soon after the second molt of the females takes place the adult males emerge, and doubtless the impregnation of the females occurs at once. After this the body of the female increases in size, becoming distended with eggs. The oviposition takes place gradually, and in those species that we have studied begins when the female is about three times as old as when the first molt occurred. In other words, the three intervals between the birth of the female and the first molt, between the latter and the second molt, and between this and the beginning of oviposition are about equal. The eggs are deposited beneath the scale, the body of the female gradually shrinking and thus making room for them. (See Plate VII, fig. 1*b* and 2*c*.) Some species, however, are viviparous.

The male scale insect during the early part of its larval life is indistinguishable from the female. The first molt occurs at the same time and is accompanied by a similar change, the male larva like the female losing its legs and antennae. The second molt is also synchronous with the second molt of the female; but here the similarity in form between the two sexes ceases. Even before this molt takes place there may be observed the formation of rudimentary limbs beneath the transparent memberless skin of the larva; and after this skin is shed the male, now in the pupa state, differs remarkably from the female. The male pupa has long antennae, and its legs and wings, although in a rudimentary state, are very large. The duration of the pupa state in those species which we have bred is short, lasting but a few days; and then after a third casting of the skin the adult male appears.

The outline figures on Plates XXI and XXII represent the insect in this stage. The anterior wings, though very delicate, are large, and enable the male to fly readily. The posterior wings are represented only by a pair of halteres. These insects resemble in this respect the flies, gnats, and other insects belonging to the order Diptera, or two-winged insects. The posterior end of the body is furnished with a style which is sometimes nearly as long as the remainder of the body, and is the external

* Rudiments of antennae are sometimes retained, as in certain species of Mytilaspis.

organ of reproduction. As our figures represent only a dorsal view, the most remarkable character of the adult, the supplementary eyes which take the place of the mouth parts, is not shown.

EXPLANATION OF CHARACTERS USED IN CLASSIFICATION OF THE COCCIDAE

Many members of this family differ so greatly from the ordinary forms of insects that in classifying them it becomes necessary to use characters peculiar to them. This is especially true of the subfamily Diaspinae, where the scale and the last segment of the female present nearly all of the tangible specific characters. Much stress has been laid by certain writers upon the characters presented by the male. But, although we have done our best, we have found little in this sex that is of value for separating closely allied species that can be put into words. We have bred the males in much greater numbers both of species and of specimens than has ever been done before by a single student. These have been figured very carefully, the drawings being made on a large scale and reduced by photography. Great care has been taken to represent accurately the shape and relative size of the different parts of the body. The results of our labor in this direction are given with the hope that in the future they may be found of more value than appears to us now. The disappointment which we have experienced in the study of the males has been relieved by the success which has attended our study of the margin of the last segment of the females of the Diaspinae. Here we have found a set of characters which have received almost no attention heretofore, but which are almost the only ones which can be relied upon for separating closely allied forms.*

SCALE.— The term *scale* is applied to the thin pellicle which covers the dorsal surface of the bodies of all the Diaspinae. It is composed in part of molted skins, of which *two* are attached to the scale of the female, and *one* to that of the male; these are termed the *exuviae.* There is also a layer composed of excretion, and, in some cases at least, of the ventral half of the molted skins between the body of the insect and the bark of the plant upon which it is. This layer varies greatly in thickness and presents in some instances specific characters. I do not find that it has been noticed by authors. In the descriptions of species I have termed it the *ventral scale.*

LAST ABDOMINAL SEGMENT.—As stated under the head of *Metamorphoses,* the members of the subfamily Diaspinae undergo a remarkable change at the time of the first molt, losing their legs and antennae, and thus becoming apparently less highly organized than in the larval state. At the same time the last abdominal segment assumes a remarkable form, becoming flattened and fringed with numerous appendages. In the male this character is transient; the form of this segment changing gradually, previous to the second molt, to that which it bears in the

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*Although I have endeavored to so describe and figure the more important species of scale insects that they may be easily recognized by any careful reader, still I am forced to state that in many cases it is useless to try to separate closely allied species by a study of the scale alone. The most reliable characters are presented by the spinnerets, and the fringing lobes, plates, and spines of the caudal segment of the adult female. In the study of these characters good work can only be done with the best of apparatus. The specimens must be carefully mounted and examined with a good microscope using a one-fifth inch objective or a higher one. We have used for our finest work a Hartnack No. 9 (equivalent to one-eleventh inch Am. objective) and a No. 5 eye piece; this combination gives a magnification of about thirteen hundred diameters.

pupa state. In the female, however, this segment becomes hardened apparently by the deposition of chitine, and the peculiar form is preserved throughout the remainder of the insect's life. In fact, so completely are these parts chitinized that their peculiar forms are preserved even after the insect is dead and the remainder of its body is so shriveled as to be unrecognizable.*

The very careful study which we have made of this segment and its appendages, embracing an examination of several thousand mounted specimens, has demonstrated that the characters here presented are very constant within the limits of each of the species which we have investigated. In fact they are the only characters upon which we have been able to place implicit confidence in separating closely allied forms. I have therefore given considerable space in the description of species to these characters. In each case the description has been based upon a study of the adult female.

Upon the dorsal surface of the segment are usually several lines of holes which are the openings of glands which execrete a part at least of the substance of which the scale is composed. I have studied specimens in which there was a thread of excretion extending from each of these openings to the scale. Although these openings are very prominent I have failed to find that they present specific characters, and so have made no use of them in classification; and have figured them in but few instances. In the more transparent species they are easily seen through the body when examining it from the ventral side, and unless a good microscope be used, the openings of the two surfaces will be confused. Near the center of the ventral surface of this segment is the *vaginal opening*, which is large, and which is represented in nearly all of our drawings of this segment.

In most species there is a greater or less number of peculiar openings arranged in groups around the vaginal orifice. These are termed *spinnerets* (*filières*) by Signoret, a term which is also applied to various other openings, tubes, and tubular spines which occur on this and other segments of the body, and which are supposed to be openings to glands which excrete the covering of these insects. The pores which are arranged in groups about the vaginal opening differ remarkably from others in being compound, each spinneret being a circular plate perforated by several small openings.†

The presence or absence of these spinnerets, the number of them in each group, and the number of groups, are characters of some value in classification. They cannot however be relied upon implicitly. The number of spinnerets in each group varies more or less in every species, and even upon the two sides of the body of the same individual. But as this variation is usually quite limited it does not render this character valueless. In most species the number of the groups of these spinnerets is either four or five. When they are five, one is situated cephalad of the vaginal opening, and two on each side of it. These groups I have designated as the anterior, anterior-lateral, and posterior-lateral, respectively. When there are only four groups, it is the anterior one that is wanting. Other forms of grouping of the spinnerets exist and will be described in the descriptions of the species in which they occur. On the posterior margin of the segment are situated numerous

* In one instance I removed from under their scales the dried bodies of scale insects which had been in a collection for twenty-five years, and found that the characters presented by this segment were perfectly preserved.

† I have observed similar compound spinnerets near the base of the oral setae in several species (*C. furfurus* and *P. pergandii*).

appendages of which three forms may be distinguished; these I have termed lobes, spines, and plates.

The *lobes* are usually the most conspicuous of the appendages of this segment. They appear to be inserted in a groove between the posterior edges of the upper and lower surfaces of this segment. But in two species which I have succeeded in dissecting (*A. obscurus* and an undescribed species) I found each lobe to consist of a prolongation of the margins of the dorsal and of the ventral walls of the segment; these prolongations being much thickened and joined at their distal extremities. This thickening of the body wall extends anteriorly for a short distance upon both the dorsal and ventral sides of the body, but chiefly upon the former. The number of these lobes varies from one to four pairs.

In some species a part of the *lateral margin* of the segment appears to be of the same structure as the lobes.

In certain species *thickenings* of the body wall occur near the prolongations of the lobes but more or less distinct from them. In each of the species which I have dissected these thickenings are on the dorsal side of the body; this point can be determined only by splitting the specimen and studying the dorsal and ventral halves of the body separately. In an unmutilated specimen the thickenings of the body wall appear like organs within the body. The number, size, and position of these thickenings afford good specific characters.

In certain species the posterior margin of the segment is incised two or three times (usually twice) on each side of the meson. These *incisions* and the edges of them (which are usually thickened) afford characters of importance. As with the thickenings described above it is difficult to determine from an unmutilated specimen upon which surface these incisions are. They are represented in all of our drawings as they appear when seen from the ventral side.

The *spines* are situated near the posterior margin of the segment. There are usually two, one on the dorsal surface and one on the ventral surface, associated with each of the lobes. Others are situated at various intervals between the lobes and the penultimate segment. In many instances these spines appear to be tubular; and I have repeatedly seen what appeared to be threads extending from them; hence they may be spinnerets.

In the descriptions the lobes and spines are numbered, beginning at the meson, the corresponding lobes of each side of the body bearing the same numbers. They are thus considered in pairs; as are the legs and wings of other insects, excepting that in numbering the lobes and spines the numbers increase cephalad instead of caudad.

Under the head of *plates* I have classed all the remaining appendages which fringe this segment. They are usually long, flattened, and more or less notched or toothed. Sometimes, however, they are hair-like or spine-like. This is especially the case on the side of the segment; here, too, the form and number are not so constant as it is between the lobes. When studying the ventral surface of this segment a clear spot on the middle line of the body is usually visible. This is the *anal opening*, and is really on the dorsal surface of the segment; its apparent position is represented in the figures, and as will be readily seen varies greatly in different species.

There are many other openings and appendages of this segment which we have not represented in our figures, as no use has been made of them in classification, and the representation of them would only tend to confuse the illustrations.

TERMS DENOTING POSITION OR DIRECTION OF ORGANS

The use of the terms upper, lower, inner, outer, before, behind, and similar expressions in the technical descriptions of animals, or of their parts, has led to so much confusion that there is a strong movement on the part of the leading zoologists in favor of a more exact anatomical nomenclature.* Although many of the terms proposed may never be adopted, others which are obviously appropriate, definite, and concise are rapidly coming into use. A few terms of this class are introduced into this report. The position and direction of all parts and organs are referred to an imaginary plane dividing the body into approximately equal right and left halves. This middle plane or any line contained therein is designated as the *meson*. The corresponding adjective is *mesal*, and the adverb *mesad*. In combination *meson* becomes *meso*. The well-known adjectives *dorsal, ventral, dextral, sinistral, lateral, proximal, distal, cephalic,* and *caudal* are used in preference to less definite terms, as are also the corresponding but less familiar adverbial forms, *dorsad, ventrad,* and so on.

METHODS OF PREVENTING THE SPREAD OF SCALE INSECTS

The facts given above suggest the following methods of preventing the spread of scale insects to orchards and other cultivated grounds not already infested by them. In planting an orchard, choose as isolated a spot as practicable, so as to be able to control as fully as possible the conditions upon which the introduction of pests depends. If isolation cannot be obtained, an effort should be made to induce the owners of neighboring orchards to join in the determination to grow clean fruit. The greatest care should be used in the purchase of trees and in the importation of buds. Before planting, thoroughly wash all such trees with some substance, as a strong solution of soap, which will destroy insects without injury to the trees; buds and scions brought from other orchards should be treated in the same way before using. The fact that trees or scions appear free from pests should not deter one from using the utmost precaution, for the untrained eye would fail to detect the early stages of these insects. Do not visit infested orchards unnecessarily; and, above all things, do not carry home specimens of scale insects as curiosities. The trees should be watched carefully, and if one is ever found to be infested with scale insects it should be destroyed at once. Remember that no better investment can be made than to burn such a tree, and that no other time is so good for doing it as the day it is first found to be infested. The system of exchange of fruit boxes which is practiced in some markets, notably in San Francisco, is a very dangerous one. Each shipper should have his boxes marked, and insist on not receiving boxes belonging to other shippers. And in any case when boxes are sent to a market where fruit from infested orchards is received they should be scalded on their return. This precaution will tend to check the spread of the codling moth and other pests as well as scale insects.

The use of fertilizers is often recommended as both a preventive of the attacks of scale insects and a remedy to be used when an orchard becomes infested. The general testimony of fruit growers is that sickly trees are much more liable to be attacked by scale insects than those which are healthy. Doubtless, in many instances, the effect of the

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* See paper by Dr. Burt G. Wilder on "A Partial Revision of Anatomical Nomenclature," Science, vol. ii, pp. 122–133.

presence of insects has been considered the cause; but in other cases, some of which have come under my observation, the sickly condition of the tree has certainly preceded the attacks of the insects. It is difficult to explain these phenomena, unless we suppose that the sap of a sickly tree is in some way more nutritious than that of a vigorous tree, for the period during which these insects can travel is so limited that they are not able to make a choice of food plant, but must, under ordinary circumstances, live or die on the plant upon which they were born. Let the explanation be what it may, the fact remains that vigorous trees are less liable to become infested by scale insects. I have also been assured by many fruit growers, and some of them men of broad experience and close observation, that by stimulating the growth of an infested tree, " the tree will throw off the scale insects." As to this I cannot speak from personal experience. But testimony of this kind is so general that I am inclined to believe that it has considerable foundation in fact. Moreover, this theory is simply the converse of the one that sickly trees are more subject to the attacks of this class of insects. In any case, be these theories true or not, a healthy tree will be better able to withstand the attacks of insects, and the use of fertilizers will aid a tree in recovering from the enfeebling effects of such attacks.

METHODS OF DESTROYING SCALE INSECTS

In many cases these pests have gained such a foothold that the destruction of a small number of trees would not suffice to free the orchards from them. And hence, to accomplish our purpose, it is necessary to be able to destroy the insects without injury to the infested trees. During the past year I have conducted many experiments with various substances which have been recommended for this purpose. In every case care has been taken to note the effect upon the plant of the substance used, as well as its efficacy as an insecticide. Next in importance to these considerations are the cost of a substance, and the relative ease with which it may be applied. These have also been carefully considered.

From the suctorial habits of this group of insects, the remedies available are evidently limited to such as destroy life by simple contact, and such as produce death when inhaled through the spiracles. The large class of poisons which require to be swallowed with the food of the insect are useless, as the food is taken from beneath the surface of the tissues of the plant, and hence beyond the reach of external applications to the plant.

Methods of applying remedies.— Certain species of scale insects confine their attacks to the bark of the trunk and larger limbs of the trees which they infest. These are very easily reached. The best method is to apply the substance used with a stiff brush, by means of which many insects may be destroyed mechanically, and the remedy brought in contact with others which are under the loose bark of the tree, and would thus be liable to escape if the remedy were applied otherwise.

But the greater number of species of this family of insects infest the bark of the smaller branches and the foliage. To reach these is a difficult matter. It can be done best by means of water and some form of force pump; the remedial agent being diluted with water and the mixture then sprayed upon the infested plants. The pump which I have used in my experiments is figured in Report for 1879, Plate XIV, consists of two brass tubes, one working telescopically within the other; a hose is fastened to one end and a rose can be attached to the other; this

rose is represented in the lower part of the figure; an arrangement of valves allows water to pass into the pump through the hose, but will not allow it to return. Thus, when the smaller tube is pulled out, the pump is filled to its greatest capacity; by pushing this tube back, the water can be ejected with considerable force through the rose in a fine spray. By using a nozzle with a single opening, such as is represented upon the pump, a stream can be thrown a greater distance. In this way the topmost leaves of any orchard tree can be reached. In applying liquids on a large scale, as upon extensive orchards, the work can be done rapidly by placing the mixture in a barrel upon a wagon, and pumping directly from this barrel. In case expensive solutions are used it will probably be found desirable to collect that part which drops from the tree while the application is being made. For this purpose an apparatus can be made of canvas or strong cotton cloth supported by a frame and so arranged that the liquid which falls on it will flow into a receptacle, and can thus be used again. In addition to the saving of the liquid which falls from the tree, the use of an apparatus of this kind would tend to cause the more thorough application of the remedy, as the operator would feel that what was not necessary to wet the trees would fall off and thus be saved. The great difficulty of wetting every part of the tree by a single application will in most cases render several applications necessary.

REMEDIES WHICH HAVE PROVED PRACTICABLE.— Although many substances have been recommended for the purpose of destroying scale insects, the results of our experiments tend to show that in most cases these substances are of but little value. A few of the agents, however, have been found to be both efficient and practicable. These are as follows:

Soap.— The value of soap as an insecticide has long been known; and the experiments which I tried with it were made chiefly for the sake of comparison with those made with other substances. The results, however, were so remarkable that I feel warranted in saying that taking into consideration its efficiency as a means of destroying scale insects, its effect upon plants, and its cost, there is at this time no better remedy known than a strong solution of soap. In my experiments whale-oil soap was used, and the solution was applied by means of a fountain pump to orange trees infested with the red scale of California. In the strongest solution used the proportions were three-fourths pound of soap to one gallon of water. The mixture was heated in order to dissolve the soap thoroughly; and the solution was applied while yet heated to about 100° F. The tree upon which the experiment was made was very badly infested, the bark of the trunk being literally covered with scales. Four days after the application of the solution I examined the tree very carefully and could find no living insect on the trunk of the tree, and only a small proportion of the coccids on the leaves appeared to be still alive. I was unable to examine the tree again personally, but three months later Mr. Alexander Craw, of Los Angeles, made a careful examination of this and some other trees upon which we had experimented, and on this one *he was unable to find any living scale insects.* Taking into consideration the extent to which this tree was infested, and the fact that but a single application of the solution was made, the result is remarkable.

In another experiment the solution was made as in the above and then an equal amount of cold water added. The tree experimented upon was similar to the one used for the former experiment. Four days after the application no living insects could be found on the trunk of the tree, and only a very few upon the leaves. In fact, the experiment was as

successful as could be expected, it being very difficult to reach every insect on the leaves by a single application. When Mr. Craw examined this tree three months later he found but few living insects on it.

As a result of all of my experiments with soap, I recommend the use of it in the proportion of one-fourth pound of soap to one gallon of water, repeating the application after an interval of a few days. If a cheap soap be used, which can be obtained for from four to six cents per pound, the cost of the remedy will not be great compared with what is to be gained.

Kerosene.— This is the best and cheapest of all agents for the destruction of insects where it can be applied without injury to crops or other property. But the injurious effects which are liable to follow the use of it when applied to living plants detracts greatly from its value. To what extent it can be safely used has not yet been fully determined.

We have tried many experiments but the results are not uniform. Spraying kerosene upon the leaves of cotton killed the plant. The bark of elm trees around which bands of felt saturated with kerosene had been applied was destroyed whenever the oil reached it.

In Jacksonville, Fla., I was shown orange trees the trunks of which had been wet with kerosene to destroy the scale insects, and the experiment resulted in the destruction of the greater part of the bark to which the oil had been applied. On the other hand, I have repeatedly applied the pure kerosene to the leaves of orange without any apparent result; even a young shoot, which although two feet in length was not more than fourteen days old, was uninjured by an application of pure kerosene which thoroughly wet every leaf so that the oil flowed from them in large drops. A bark louse (*Lecanium hesperidum*) which was very abundant upon ivy on the department grounds was destroyed by the application of pure kerosene with no apparent bad results to the vine.

The experience of Mr. Saunders in the use of kerosene in the orange house of the department has extended through several years. He gives the results of his experiments as follows*:

Several years ago the department imported from Europe a collection of the Citrus family, embracing many varieties of the orange, lemon, lime, &c. The plants were in a very bad condition when taken out of the packages, owing to detention on the voyage and other causes; most of them were denuded of foliage and very scant of roots. They were at once planted in pots and placed under suitable conditions for growth. It soon became evident that they were badly infested with a scale insect which greatly retarded their growth and prevented their propagation and distribution. After the failure of many attempts to utterly eradicate this insect, the collection may now be said to be entirely rid of it. This has been effected by the persistent use of a small portion of coal oil applied in water. About one gill of astral oil in five gallons of water applied to the plants through a syringe on alternate days for several months has destroyed the insects without injury to the plants; weaker solutions seemed ineffective, and when the oil was increased to an appreciable degree, the young leaves and tender shoots of the oranges were injured.

The success attending Mr. Saunders's use of coal oil is due, I believe, to more persistent efforts than most horticulturists would be willing to make. Not only was the remedy thoroughly applied, but it was found necessary to repeat the application very many times.

The following experiments indicate what may be expected from single applications of this remedy:

A single application of kerosene and water, in the proportions given above, to a lime tree, destroyed only a small part of the scale insects upon it. One part of kerosene suspended in one hundred and fifty parts of water was atomized over *Lecanium hesperidum* on ivy, but no

* Report of Department of Agriculture, 1878, p. 205.

effect on the insects or foliage was discoverable, although the plant was examined daily for several weeks. Some of the same mixture was applied to mealy bugs on young orange leaves with no results. One part of oil to seventy-five of water was similarly used, but neither the insects nor the foliage were injured. One part of oil to fifty parts of water was equally inefficient when applied to Lecanium. A small quantity of pure kerosene was then atomized over the scale insects on ivy. Four days later the insects were found to be dead and the vine uninjured. The experiment was repeated with similar results. Pure kerosene sprayed over a colony of the woolly apple-louse (*Schizoneura lanigera*) killed the insects at once without injuring the branch of Crataegus upon which they were.

Many experiments similar to the last two were tried with similar results. Still, I am unwilling to recommend the use of pure kerosene upon living plants.

The application of kerosene mixed with water is attended with obvious difficulties. The method adopted by Mr. Saunders is to place the kerosene and water together in a pail or tub, and then thoroughly mix the liquids by syringing a syringeful into the barrel several times and then, filling the syringe quickly, throw the mixture upon the trees before the oil and water separate. The great trouble attending this method of applying kerosene has led to many efforts to make an emulsion of this substance. As to the result of these efforts Professor C. V. Riley made the following statement in the Scientific American of October 16, 1880:

> Nothing is more deadly to the insect in all stages than kerosene or oils of any kind, and they are the only substances with which we may hope to destroy the eggs. In this connection the difficulty of diluting them, from the fact that they do not mix well with water, has been solved by first combining them with either fresh or spoiled milk to form an emulsion, which is easily effected; while this in turn, like milk alone, may be diluted to any extent so that particles of oil will be held homogeneously in suspension. Thus the question of applying oils in any desired dilution is settled, and something practicable from them may be looked for.

Soon after the publication of this article I planned experiments based upon the statement in it to ascertain definitely what proportion of kerosene suspended in water by the aid of milk was most desirable for use in the destruction of scale insects. I found at once that the emulsion of milk and kerosene which I made could not be diluted with water to any great extent. Fully realizing the importance of the matter, I then made a series of more than fifty very careful experiments in order to ascertain how the desired dilution of the emulsion could be obtained. The results of these experiments were as follows:

An emulsion of kerosene and milk can be easily made by placing the fluids together in a bottle and shaking them violently for several minutes; about three minutes is the time usually required. The quantity of milk used should be at least equal to that of the kerosene. The best results were obtained when the kerosene formed only one-third of the mixture, but equal parts of kerosene, milk, and water gave as good results as one part of kerosene to two parts of milk.

For example, in one series of experiments I was unable to make an emulsion of equal parts of oil and milk; but by the addition of a third part of *either water or milk* I was able in each case to make a good emulsion. These emulsions were of a thick creamy consistence, and were very stable, no indication of a separation of the oil from the milk in one case, or from the milk and water in the other, being observable even after the emulsion had stood twenty-four hours. But as soon as water was added to the emulsion in any considerable quantity the oil

or the oil and milk together floated on the surface of the water; and no amount of shaking would serve to mix the liquids so that the mixture would be stable. It is true that in some of the experiments the emulsion separated from the water less readily than oil alone would; but in each case the mixture was of such a nature that it was necessary to stir it constantly in order to keep the oil suspended in the water.

Cole's Insect Exterminator.—This is the name given to a compound which is in the market and which is highly recommended as an insecticide. Its cost is too great, however, to admit of its use except on a small scale, as in conservatories. The results of our experiments show that it is very effectual as an insecticide, and that it is harmless to growing plants, thus being all that is claimed for it. An analysis of it shows that it may be closely copied by dissolving 2 to 2.5 per cent of green soap in 100 parts of 50-per-cent alcohol.

Tobacco.— A decoction of tobacco made by steeping .5 gram of Durham smoking tobacco in 15 cc. of water was fairly successful. Where tobacco can be obtained cheaply it is likely to prove of practical value for the destruction of scale insects; at least it merits a fair trial on a large scale in the field.

Snuff and sulphur.—Equal parts by bulk of smoking tobacco and flowers of sulphur were ground together in a mortar till thoroughly mixed. This compound was perfectly successful when dusted over *Lecanium hesperidum* when wet; and it adhered to the plant for a long time notwithstanding rain. Still this does not seem to me to be a remedy that will admit of successful and economical application on a large scale. It may be useful in conservatories, and upon ornamental plants.

Lye.—A small number of experiments were tried with lye; these were only partially successful. I found later, however, that lye has been used to a considerable extent in the vicinity of San José, Cal., with good results. Dr. Chapman, of that city, recommends* the use of concentrated mercantile lye in the proportion of one pound of lye to from two to four gallons of water, but suggests that the strongest solution should only be applied when the tree is dormant. I saw most excellent results in the orchard of Mr. V. C. Mason from the use of the following mixture: One pound concentrated lye, one pint gasoline or benzine, half pint oil, five gallons water.

Results of experiments with other substances.—By far the greater number of the substances with which we experimented proved to be of little or no value. In the case of some of them which have been very widely recommended by the agricultural press, we give the results of our experiments. These results are important, as they will enable the horticulturist to avoid loss of time and money in the application of inefficient substances.

Pyrethrum.— Through the kindness of Mr. G. N. Milco, of Stockton, Cal., I was furnished with an abundant supply of this valuable insecticide, and I made more careful and extended experiments with it than with any other substance. As a result of these experiments I am forced to state that, although for the destruction of certain classes of insects there is nothing better than a good quality of fresh pyrethrum powder, for the destruction of scale insects it is of very little, if any, value.

Dry pyrethrum was blown over the leaves of a tree badly infested with *Lecanium hesperidum* and *L. oleae*; so large a quantity of the powder was used that the upper surface of the leaves was made yellow with it. Although the coccids were young, many of them still crawling over the

* Pacific Rural Press, April 9, 1881.

surface of the leaves, but few were killed by the powder; and since many lady-bug larvae (Coccinellidae) which prey upon these coccids, and many specimens of a chalcis fly (*Tomocera californica*) the larvae of which destroy the eggs of the black scale (*L. oleae*) were destroyed by the powder, the application of it appeared to do more harm than good. During this experiment, which was in the open air in Southern California, a layer of paper was spread upon the ground under the tree. In about ten minutes after the application of the powder the chalcis flies and coccinellid larvae began to fall upon the paper, and I believe that the number of these beneficial insects which were destroyed was greater than the number of coccids.

Infusions were made in numerous ways, with hot water and with cold, by steeping and by boiling, and of various strengths. In some the proportion of pyrethrum was nearly one-fourth pound to the gallon of water. Although the infusions were more destructive to coccids than the dry powder, in no case were they sufficiently so to be considered successful, especially when the fact that the cost of the infusion was from ten to fifteen times as great as the cost of a solution of soap which was much more efficient.

The tincture of pyrethrum was found to be much more effectual than either the infusion or the dry powder; but the cost of making a tincture precludes its use on a large scale. A tincture of the *leaves and stems* of pyrethrum was furnished me by Mr. Milco. This also was found to be very efficient; which is a very interesting fact, as it indicates that the active principle of the plant is not confined to the flowers, a point worthy of further investigation.

Alcohol.— Commercial alcohol sprayed over scale insects produced no apparent effect. The experiments were tried for the sake of comparison with those made with tinctures, in order to ascertain if the greater efficiency of the tinctures was due to the presence of the alcohol with which they are made.

Ammonia.— Dilute *aqua ammonia* was found to be valueless for the destruction of coccids, as it injured the plants more than the insects.

Carbolic acid.— A large number of experiments were tried with aqueous solutions of carbolic acid. This substance was found to be of little value in destroying coccids and quite liable to injure the foliage of the plants.

Sulphur.—Although this substance is very useful for destroying the mycelium of fungi, our experiments indicate that it possesses little value as an insecticide. It forms, however, the basis of a large part of the nostrums used by the quacks who doctor fruit trees. A common way of applying it is to bore a hole, often one inch in diameter and six inches deep, into the trunk of the infested tree; then, after putting a considerable quantity of flowers of sulphur into this hole, it is closed with a wooden plug. It is claimed that the sulphur will be taken up by the sap and carried to every part of the tree, thus reaching and destroying every insect pest that infests it. Apparently no account is taken of the important facts that the sulphur is usually placed far inside of the cambium layer, and consequently where there is but little if any circulation of the sap; and that as sulphur is insoluble in water, it would not be taken up by the sap even under the most favorable circumstances.*

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* I removed from an orange tree in Florida a quantity of flowers of sulphur which had been placed in it in the way described two years previously. The sulphur was unchanged in nature, and, as I was assured by the owner of the tree, undiminished in bulk.

USEFUL PRODUCTS OF THE COCCIDAE

Although the occasion for this report is the great injury to agriculture caused by certain species of scale insects, or bark lice, it should be borne in mind that there are insects belonging to this family which are beneficial to man. In some instances these insects or their products have been of great commercial importance, especially in ancient times; and to this date the products of certain species are used extensively.

The dyestuff known as kermes, or *Granum tinctorium,* is made from the dried bodies of the females of *Coccus ilicis* of Linnaeus, a species of bark louse which lives upon a small evergreen oak (*Quercus coccifera*), a tree which is native of Asia and the countries bordering on the Mediterranean. This dye has been in use ever since the time of Moses; and Pliny states that the inhabitants of Iberia paid to the Romans half their tribute in kermes. The use of this dye has, however, been superseded to a great extent by cochineal, which gives colors of much greater brilliancy. Cochineal is also an insect belonging to this family; it is the *Coccus cacti* of authors, and is a native of Mexico. It feeds upon various species of the Cactaceae, more especially *Opuntia coccinilifera.* Although this insect is a Mexican species, it is now cultivated in India, Spain, and other countries, and I have received living specimens which were collected upon a wild cactus near Fernandina, Fla. The dyestuff consists of the female insects, which, when matured, are brushed off the plants, killed, and dried. The entire insect is used. From cochineal, lake and carmine are also prepared. Cochineal is now being superseded by aniline dyes, which are made from coal tar.

The scarlet grain of Poland (*Porphyrophora polonica*) is still another bark louse which has been used to a considerable extent as a dyestuff.

The stick-lac of commerce, from which shell-lac, or shellac, is prepared, is a resinous substance excreted by a bark louse known as *Coccus lacca* (*Carteria lacca* Ker.), which lives upon the young branches of several tropical trees, especially *Ficus Indica, F. religiosa,* and *Croton lacciferum.* And the coloring agent known as lac dye is also prepared from stick-lac.

Another true lac insect occurs in Arizona upon the stems and branches of *Larrea mexicana.* Judging from the specimens in the museum of this department, the lac occurs on this plant in sufficient quantity to be of economic importance.

A bark louse which was described under the name of *Coccus manniparus* (*Gossyparia maniparus* Sign.), "is found upon *Tamarix mannifera* Shr., a large tree growing upon Mount Sinai, the young shoots of which are covered with the females, which, puncturing them with their proboscis, cause them to discharge a great quantity of a gummy secretion, which quickly hardens and drops from the tree, when it is collected by the natives, who regard it as the real manna of the Israelites" (Westwood).

China wax is another substance for which we are indebted to this family. It is the excretion of an insect known as Pe-la (*Ericerus Pe-la* Westwood). In fact, many species of this family excrete wax in considerable quantities. I have found three species in this country which, if they can be easily cultivated, produce wax in sufficient quantities to be of economic importance.

DESCRIPTIONS OF SPECIES

Subfamily DIASPINAE

Genus **ASPIDIOTUS** Bouché

This genus includes species of Diaspinae in which the scale of the female is circular or nearly so, with the exuviae at or near the center; and the scale of the male somewhat elongated, with the larval skin at one side of the center or near one extremity. The last segment of the female usually presents four groups of spinnerets; in a few species there are five groups, and in some they are wanting.

ASPIDIOTUS ANCYLUS Putnam

(Plate XIV, fig. 3; Plate XXI, fig. 2, 4)

Diaspis ancylus Putnam. Transactions of the Iowa State Horticultural Society for 1877, vol. xii, p. 321.
Aspidiotus ancylus Putnam. Proceedings of Davenport Academy, vol. ii, p. 346.

Scale of female.— The scale of the female is usually slightly wider than long, although nearly circular, with the exuviae laterad of the center, and covered with a thin layer of excretion. This film is white, but it is easily removed, leaving the brick-red exuviae exposed. That part of the scale immediately surrounding the exuviae is dark gray, almost black; the margin of the scale is light gray; the whole scale has a reddish tinge. It measures about 1.4 mm. in length and 1.3 mm. in width. Ventral scale white and very delicate.

Female.— The female is pale yellowish or pale orange in color, marked with translucent spots. The outline of the body before oviposition is ovate, but becomes more or less circular after the insect begins to oviposit. The last segment presents the following characters (Plate XIV, fig. 3):

There are four or five groups of *spinnerets.* The anterior group, when present, varies from a single spinneret to six, but it rarely consists of more than three; the anterior laterals vary from six to fourteen; the posterior laterals vary from five to eight.

Only one pair of *lobes* present, these are large; each is notched at about the middle of the lateral margin; occasionally there is a small notch near the end of the lobe on the mesal margin.

There are two *incisions* of the margin of the ventral surface on each side of the meson, one just laterad of the lobe, and one laterad of the second spine. The part of the body wall bounding these incisions is conspicuously thickened.

There are two *plates* caudad of each incision; these plates are usually simple, but are sometimes toothed; occasionally there is a third plate in one or more of these places. There are three to four irregular slender plates between the third and fourth pairs of spines. The first, second, and third pairs of spines are situated as in allied species; the fourth pair is at two-thirds the distance from the lobes to the penultimate segment. Described from five specimens from maple, two from peach, seven from osage orange, twelve from hackberry, fifteen from ash, and eleven from *Staphylea trifoliata.*

Variety.— A form of Aspidiotus was found, the scales of which I am unable to distinguish from those of *A. ancylus;* but the last segment of

the female presents the following difference from the typical form of this species: There are no plates between the third and fourth pairs of spines; and the vaginal opening is mesad the anterior spinnerets of the posterior lateral groups, instead of the posterior members of the same groups. The variation in the number of the spinnerets is greater in my specimens of the variety than in those of the typical form, there being in some cases seventeen on the anterior laterals, and nine on the posterior laterals. Described from twenty-one specimens from linden, eleven from beech, eighteen from oak, and four from water locust.

Scale of male.— The scale of the male resembles that of the female in color, but is smaller and more elongated. Length 1.2 mm., width 0.6 mm.

Male.— The male is easily distinguished from all other species known to us by the small size of its wings. We have bred numerous specimens from seven species of plants: maple, Staphylea, hackberry, ash, osage orange, peach, and water locust. These males show considerable variation, and for a time I believed that I had two species. The extreme forms are represented by figures 2 and 4, Plate XXI. In each the color of the body is orange yellow; in the former, which was bred from peach, the thoracic band is dark brown, and the distal joints of the antennae are not enlarged; in the latter, which was bred from ash, the thoracic band is of the same color as the remainder of the body, and the distal joints of the antennae are conspicuously enlarged. These two forms shade into each other, and each was bred from plants which were infested by the typical females only.

Habitat.— Davenport, Iowa (Putnam), Washington, and western New York.

ASPIDIOTUS AURANTII Maskell

THE RED SCALE OF CALIFORNIA

(Plate III, fig. 1; Plate XII, fig. 1; Plate XIII, fig. 1)

Aspidiotus aurantii Maskell. Trans. and Proc. of the New Zealand Institute, vol. xi, p. 199.

Aspidiotus citri Comstock. Canadian Entomologist, vol. xiii, p. 8.

Scale of female.— This scale resembles that of *Aspidiotus ficus* in shape, size, and the presence of the nipple-like prominence, which indicates the position of the first larval skin; but it can be readily distinguished from the scale of that species as follows: It is light gray, and quite translucent; its apparent color depending on the color of the insect beneath, and varying from a light greenish yellow to a bright reddish brown; the central third (that part which covers the second skin) is as dark and usually darker than the remainder of the scale; and when the female is fully grown the peculiar reniform body is discernible through the scale, causing the darker part of the outer two-thirds of the scale to appear as a broken ring. (Plate III, fig. 1*b*.)

Female.— The female is light yellow in color in the adolescent stages, becoming brownish as it reaches maturity. When fully developed the thorax extends backward in a large rounded lobe on each side, projecting beyond the extremity of the abdomen, and giving the body a reniform shape. The last abdominal segment presents the following characters (Plate XII, fig. 1):

I have been unable to detect the presence of the groups of *spinnerets,* although I have examined many specimens prepared in various ways.

There are three pairs of well-developed *lobes.* The lobes of the first pair are abruptly narrowed at about half their length; the notch on the

mesal margin is often nearer the distal end of the lobe than that of the lateral margin. The lobes of the second and third pairs are abruptly narrowed at half their length on the lateral margin, and often bear a notch on the median margin near the distal end. Laterad of the most lateral plate is a triangular lobe of the *margin of the segment,* which is serrate.

The *plates* are all deeply fringed; those between the first pair of lobes on their distal margins, the others on their lateral margins. They are all well developed, exceeding the lobes in length, and are situated as follows: Two between the first pair of lobes, two between the first and second lobes of each side, two between the second and third lobes, and three between the third lobe and the lobe of the margin of the body. The first plate laterad of the second lobe, and the three plates laterad of the third lobe are each deeply bifurcated, and each bifurcation is fringed on the lateral margin.

On the ventral surface there is a *spine* near the base of the lateral margin of each of the four lobes except the first; there are also about three small slender spines on the margin of the body near the penultimate segment. On the dorsal surface there is a spine with each lobe. The first spine is very slender and inconspicuous, but as long as the lobe; it is situated at the base of the lateral margin of the lobe in such a manner that it can be moved either above or below the lobe. Each of the other spines is situated near the middle of the base of the lobe it accompanies.

Egg.— I have not seen the eggs of this species, excepting those taken from the body of the female. And as I have repeatedly found young larvae under the scales I am led to believe that the species is viviparous.

Scale of male.— The scale of the male resembles that of the female, excepting that it is only one-fourth as large; the posterior side is prolonged into a flap, which is quite thin; and the part which covers the larval skin is often lighter than the remainder of the scale.

Male.— The male is light yellow, with the thoracic band brown, and the eyes purplish black. The outline drawing on Plate XIII, figure 1, represents the shape of the various organs.

Habitat.— I have observed this species in several groves at San Gabriel and Los Angeles, Cal. At the first-named place, where it is very abundant, it is said to have first appeared on a budded orange tree which was purchased by Mr. L. J. Rose, at one of the hothouses in San Francisco. At Los Angeles it appears to have spread from six lemon trees which were brought from Australia by Don Mateo Keller.

At first I considered this an undescribed species, as I could find no description of it either in American or European entomological publications. I therefore described it in the Canadian Entomologist under the name of *Aspidiotus citri.* Afterwards I obtained copies of the papers *On some Coccidae in New Zealand,* by W. M. Maskell, published in the Transactions and Proceedings of the New Zealand Institute, and found that he had described an insect infesting oranges and lemons imported into New Zealand from Sydney which was either identical with or very closely allied to the red scale of California. I at once sent to Mr. Maskell for specimens of the species described by him. These have just been received and prove to be specifically identical with those infesting citrus trees in California. Thus the question as to source from which we derived this pest is settled beyond a doubt.

I have found *Aspidiotus aurantii* only on citrus trees. It infests the

trunk, limbs, leaves, and fruit. The infested leaves turn yellow, and when badly infested they drop from the tree. This species spreads quite rapidly; and from what I have seen of it, I believe that it is more to be feared than any other scale insect infesting citrus fruits in this country. As illustrating the extent of its ravages in Australia, Dr. Bleasdale told me of a grove of thirty-three acres which nine years ago rented for £1800 per year, and for which three years ago only £120 rent could be obtained.

Specimens of this insect colonized on orange trees in the breeding room of the department passed through their entire existence in a little more than two months; hence it is probable that in the open air in southern California there are at least five generations each year, and possibly six. The mode of the formation of the scale in this species very closely resembles that of *A. ficus,* described at length in this report. The ventral scale, however, reaches a greater degree of development in *A. aurantii* than in *A. ficus.* At first it consists of a very delicate film upon the leaf; when the second molt occurs it is strengthened by the ventral half of the cast skin, the skin splitting about the margin of the insect, the dorsal half adhering to the dorsal scale and the ventral half to the ventral scale. Later, after the impregnation of the female, the ventral scale becomes firmly attached to the dorsal scale and to the insect; so that it is almost impossible to remove an adult female from her scale.

ASPIDIOTUS CONVEXUS, new species

THE CONVEX SCALE

(Plate XII, fig. 8)

This species, which is very common on the bark of the trunk and limbs of the native willows in California, very closely resembles *Aspidiotus rapax* in the shape and color of its scale. The resemblance of the two species is so great that at first I considered them identical, and concluded that *A. rapax* had spread to the cultivated trees in California from the native willows of that State. But a careful study of the structure of the two forms shows them to be specifically distinct. The most striking differences are those presented by the last abdominal segment of the female. In this species there are four groups of spinnerets; the superior laterals consisting of about seven, and the inferior laterals of about four. In *A. rapax* the groups of spinnerets are wanting.

In this species the plates are very much shorter than in *A. rapax,* and very closely resemble the plates in *A. ancylus.* But *A. convexus* differs greatly from *A. ancylus* in the shape and color of the scale and in the wings of the male being long. Described from seven females, two males, and very many scales.

ASPIDIOTUS CYDONIAE, new species

THE QUINCE SCALE

(Plate XIV, fig. 1)

Scale of female.— The scale of the female is indistinguishable from that of *Aspidiotus rapax,* described in this report.

Female.— The last segment of the body of the female presents the following characters:

There are four groups of *spinnerets.* The anterior laterals consist of eight or nine each, and the posterior laterals of from five to seven each.

There are only one pair of *lobes,* the median, visible; these are well developed. Each lobe is notched on each side; the notch on the mesal margin is slightly distad the one on the lateral margin.

The margin of the ventral surface of the segment is deeply *incised,* as in *A. rapax* and allied species, there being two incisions on each side of the meson.

The *plates* are of two kinds; the first is simple, tapering, and rather short; the second is toothed and long, extending caudad as far as the tips of the median lobes. Of the first kind, there are two between the median lobes, one on each side between the incisions, and from one to three laterad of the second incision. Of the second kind, there are on each side two caudad of the first incision, and three caudad of the second incision.

The *spines* of each surface are situated as follows: first, near the base of the lateral margin of the lobe; second, between the first and second incisions; third, laterad of second incisions; fourth, about midway between the third and the penultimate segment. Described from eighteen females.

Habitat.— Upon quince in Florida.

This species is very closely related to *A. rapax* and *A. convexus.* It is easily distinguished from the former by the presence of the groups of spinnerets, and from the latter by the number of incisions in the posterior margin of last segment of female, there being three pairs in *A. convexus,* and only two in *A. cydoniae,* and in the length and size of the plates. (Compare Plate XII, fig. 8, and Plate XIV, fig. 1.)

ASPIDIOTUS FICUS Riley MSS.

THE RED SCALE OF FLORIDA

(Plate III, fig. 2; Plate XII, fig. 2; Plate XIII, fig. 2; Plate XXI, fig. 3)

Chrysomphalus ficus Riley MSS. Ashmead, American Entomologist, 1880, p. 267.
Aspidiotus ficus Comstock, Canadian Entomologist, vol. xiii, p. 8.

Scale of female.— The scale of the female is circular, with the exuviae nearly central; the position of the first skin is indicated by a nipple-like prominence, which in fresh specimens is white, and is the remains of a mass of cottony excretion, beneath which the first skin is shed. The part of the scale covering the second skin is light reddish brown; the remainder of the scale is much darker, varying from a dark reddish brown to black, excepting the thin part of the margin, which is gray. When fully grown the scale measures 2 mm. (.08 inch) in diameter. In some specimens the part covering the exuviae is depressed, and when the scale is removed from the leaf and viewed under a microscope with transmitted light, the exuviae, which are bright yellow, show through this part, causing it to appear as described by Mr. Ashmead. This scale is represented on Plate III, figure 2; natural size, figure 2*a*, enlarged.

Female.— The body of the female is nearly circular; it is white, marked with irregular yellow spots. The last segment presents the following characters (Plate XII, fig. 2):

There are four *groups of spinnerets*; the anterior laterals consist each of about eight, and the posterior laterals of about four.

There are three pairs of well-developed *lobes*. The first and second lobes of each side are abruptly narrowed toward their posterior extremities on the lateral edges at about one-half their length; the third lobe is narrowed by a succession of notches on its lateral margin; all the lobes are widened slightly toward their bases on their mesal margins.

The *lateral margin* of the segment appears to be of the same structure as the lobes; it is serrate, deeply notched two or three times, and ends posteriorly in a lobe.

There are six *thickenings of the body wall* on each side of the meson. These are linear, oblong, with the anterior ends rounded and slightly expanded, and are more or less nearly parallel with the meson. One arising from the mesal margin of first lobe exceeds it a little in length; one from the lateral margin of the same lobe extends nearly to the anus; one each from the mesal margins of the second and third lobes are about twice the length of the lobes, and with the anterior extremities farther from the meson than the posterior; one from a point about midway between the second and third lobes extends anteriorly beyond any of the other thickenings; and finally one from the lateral margin of the third lobe is short, inconspicuous, and sometimes wanting.

Between the first pair of lobes are two wide oblong *plates,* with the distal margin of each deeply fringed; between the first and second lobes of each side are two, and between the second and third lobes are three similar plates; between the third lobe and the one at the end of the thickened lateral margin are three large compound plates, each consisting of two long branches, which are toothed deeply and irregularly on their lateral edges.

On the ventral surface near the margin of the segment are situated four pairs of *spines,* there being a spine at the base of the lateral margin of each lobe, including the lobe of the thickened margin of the segment described above. On the dorsal surface there are only three pairs of spines, none being present on the first pair of lobes; each spine is situated near the middle of the base of the lobe it accompanies.

Egg.— The eggs are pale yellow.

Scale of male.— The scale of the male is about one-fourth as large as that of the female; the posterior side is prolonged into a thin flap, which is gray in color; in other respects the scale appears like that of the female. (Plate III, fig. 2*b*.)

Male.— The male is light orange-yellow in color, with the thoracic band dark brown and the eyes purplish black. It very closely resembles the males of *A. aurantii,* but differs from that species in being a smaller insect, with shorter antennae, longer style, wider thoracic band, and with the pockets of the wings for the insertion of the hair of the poisers farther from the body.

Development of the insect and formation of the scale.—The development of this insect from the egg to the adult state was followed through five generations. I give, however, only the substance of a part of the notes taken on a single brood — the second one observed — as that will be sufficient for our purpose. The observations were made upon specimens which were colonized on small orange trees in pots in my office in Washington. The rate of the development of the insects was probably slower than would have been the case in the open air in Florida.

April 12, 1880, specimens of orange leaves infested by this scale were received from Mr. G. W. Holmes, Orlando, Fla. At this date males were found both in the pupa and adult state. The females also varied in size, and some of them were ovipositing. Eggs were placed on an orange tree for special study.

April 13, the eggs began to hatch. The newly hatched larva (Plate III, fig. 2*c*) is broadly oval in outline and yellow in color. The antennae are five-jointed; the three basal joints are very short and nearly equal in length; the fourth and fifth joints are each longer than the three basal joints together. The fifth joint is strongly tuberculated at tip so as to appear bifurcated. The eyes are prominent and of the same color as the body. The young larvae are quite active, but they settle soon after hatching. Some settled the same day that they hatched.

April 14, it was found that the young lice, although only twenty-four hours old, had formed scales which completely concealed them from sight. These scales resembled in appearance the fruiting organs of certain minute fungi. They were white, circular, convex, with a slightly depressed ring around the central portion (Plate III, fig. 2*d*); their texture was quite dense, and they were not firmly attached to either the insect or the leaf, a slight touch being sufficient to remove them without disturbing the larvae. The larvae had not changed in appearance, and were able to move their legs and antennae.

April 15, the lice had not changed perceptibly. The scales had become higher and more rounded.

April 16, the lice had contracted considerably, being now nearly circular, at least as broad as long; in other respects there was no apparent change. The scales were found to vary somewhat; those most advanced having the central portion covered with a loose mass of curled white threads (Plate III, fig. 2*e*).

April 17, there was apparent no further change in the larva; but the mass of threads covering the central part of the scale was found in some specimens to have greatly increased in size, equaling in height three or four times the width of the scale. This mass is cottony in appearance, and in those specimens where it is largest is more or less in the form of a plate twisted into a close spiral (Plate III, fig. 2*f*).

April 19, not much change was apparent in the larva, but the mass of cottony excretion upon some of the scales had increased enormously; so that in some cases it extended in a curve from the scale to a point five times the width of the scale above the leaf and down to the leaf.

April 20, no important change was observed either in the larvae or scales.

April 21, it was observed that the larvae had become more or less transparent, and marked with large irregular yellow spots near the lateral margin of the head and thorax, and with a transverse row of similar spots across the base of the abdomen; the tip of the abdomen is very faintly yellow.

April 22, no important change was noted.

April 23, it was observed that the scales appeared faintly reddish in color with the center white; the reddish color, however, was due in part to the body of the larva, which is now orange-red, showing through the scale. It should be noted that in only a part of the specimens did the cottony mass become enlarged as represented in figure 2*f*. The greater part of the scales remained until this date of the form shown in figure 2*e*, and the cottony spirals have now disappeared, probably having been blown away.

April 24, some of the larvae had become deep orange in color.

April 26, most of the scales had become deep orange in color with the central part white; some had at the center a small nipple-like protuberance; others still preserved a short tuft of a cottony excretion. This tuft is either removed by wind or otherwise, or it becomes compact, melted, as it were, to form the nipple-like projection referred to above.

April 28, the insects appeared as they did two days ago; the scales had become very tough, and it was with difficulty that they could be removed from the insect.

April 30, the insects still remained apparently unchanged. Some of the scales were only about one-half as large as others, and still remained perfectly white; these proved to be male scales. All the scales at this date had an elevated ring on the disk with a central nipple.

May 3, many of the larvae began to show that they were about to molt, the form of the next stage being visible through the skin of the insect.

May 5, nearly all of the larvae had molted; they were now orange-yellow, with the end of the body colorless. The last abdominal segment now presents the excretory pores which are represented in the drawing of the corresponding segment of the adult female (Plate XII, fig. 2). The molted skin adheres to the inside of the little scale, and therefore cannot be seen from the outside. The scales are now pink, or rose-colored, with the center white.

May 14, the insects had become a somewhat paler yellow, with the anal segment slightly darker. Most of the scales were now dark purple. On removing an insect a very delicate round white plate was observed adhering to the leaf where the mouth parts were inserted.

May 18, the male scales were fully grown. At this stage they were dark reddish brown in color, with the center white, and the posterior side, which is elongated, gray. At this date some of the males had transformed to pupae; others were still in the larva state; these larvae were covered with roundish, more or less confluent yellow spots, leaving only the margin colorless; the end of the body was pale orange. The newly transformed pupae resembled in markings the larvae just described. None of the females had yet molted the second time; their color was deep orange.

May 21, nearly all of the males had changed to pupae. It was observed that the last larval skin is pushed backwards from under the scale, to the edge of which it frequently adheres.

May 24, none of the male pupae had transformed to the adult state.

May 29, it was found that during the five days previous more than one-half of the males had issued, and the remainder, though still under the scales, were in the adult state. It was now forty-seven days from the time the larvae hatched.

June 2, no males could be found; the females were about one-half grown, and were whitish with irregular yellow spots.

June 9, eggs were observed within the body of a female.

June 17, it was found that one of the females had deposited nine eggs, of which six had hatched. This is sixty-six days from the hatching of the egg, and probably about twenty days after impregnation of the female.

The insects of this brood continued to oviposit until July 1.

Number of generations per year.— This insect, living on orange trees in a room on the north side of a building in Washington, passed through five generations in less than one year; the average time occupied by a single generation was a little less than seventy days. It is probable that in the open air in Orange County, Florida, there are at least six generations each year.

Habitat.— Although I have carefully explored many orange groves in Florida and California, and have had an extensive correspondence with orange growers, I have been unable to find this species in the last-named State, and have found it only in a single grove in Florida. This

is the grove of Messrs. Holmes and Robinson, near Orlando, in Orange County. The insects were first observed here in the spring of 1879 on a sour-orange tree which was brought from Havana, Cuba, in 1874. On learning these facts I sent specimens to a friend at Havana in order to ascertain if the species occurred there. He at once returned me other specimens with the information that it is a very common pest in public gardens of that city.

This species infests the limbs, leaves, and fruit indiscriminately. In the grove of Messrs. Holmes and Robinson it has spread slowly. The large trees which are infested do not seem to suffer much from it, but the young trees are greatly injured by it. Mr. Holmes considers the disfiguring of the fruit as the worst feature of the pest. The insect has multiplied to such an extent upon the trees upon which I colonized it in my breeding-room, that nearly all of them have been destroyed. The species is certainly one that is greatly to be feared, and there is no doubt that it would be a good investment for the orange growers of Florida to eradicate the pest, even if in doing so it is found necessary to purchase and destroy all infested trees. This could be done now easily, but if delayed a few years the species will doubtless become permanently established.

ASPIDIOTUS JUGLANS-REGIAE, new species

THE ENGLISH WALNUT SCALE

(Plate XIV, fig. 2)

Scale of the female.— The scale of the female is circular, flat, with the exuviae laterad of the center; it is of a pale grayish brown color; the exuviae are covered with secretion; the position of the first skin is indicated by a prominence which is pink or reddish brown. The ventral scale is a mere film which adheres to the bark. Diameter of scale, 3 mm. (.13 inch).

Female.— The color of the female when fully grown is pale yellow with irregular orange-colored spots; oral setae and last segment dark yellow. This segment presents the following characters:

There are either four or five groups of *spinnerets*; the anterior group is wanting or consists of from one to four spinnerets, the anterior laterals consist of from seven to sixteen, and the posterior laterals of from four to eight.

There are two or three pairs of *lobes*. The median lobes are well developed, but vary in outline; the second lobe of each side is less than one-half as large as the median lobes, elongated, and with one or two notches on the lateral margin; the third lobe is still smaller and pointed, or is obsolete.

There are two pairs of *incisions* of the margin, one between the first and second lobes of each side, and one between the second and third lobes; they are small, but are rendered conspicuous by the thickenings of the body wall bounding them.

The *plates* are simple, inconspicuous, and resemble the spines in form. The larger ones are situated one caudad of each incision.

The *spines* are prominent, especially those laterad of the second and third lobes; the fourth spines are a little nearer the first lobes than the penultimate segment; and the fifth are near the penultimate segment; there is also a spine at or near the union of the last two segments.

Scale of male.— The scale of the male resembles that of the female in

color; it is elongated, with the larval skin near the anterior end; this skin is covered by excretion, but its position is marked by a rose-colored prominence, as in the scale of the female; the anterior part of the scale is much more convex than the posterior prolongation, which is flattened. There is a rudimentary ventral scale in the form of two narrow longitudinal plates, one on each side of the lower surface of the scale. Length, 1.25 mm. (.05 inch).

Male.— Only dead males have been found; these were too much shriveled to be of use for description.

Habitat.— On the bark of the larger limbs of English walnut (*Juglans regia*), at Los Angeles, Cal. Described from sixty-three females, and many scales of each sex.

My attention was called to this interesting species by Mr. J. W. Wolfkill, of Los Angeles, who rendered me valuable assistance in my investigations in that locality.

There are in the collection of the department specimens of Aspidiotus from locust, pear, and cherry, from New York and District of Columbia, which apparently belong to this species.

ASPIDIOTUS NERII Bouché

Aspidiotus nerii Bouché. Schädl. Gart. Ins. (1833), 52.
Diaspis bouchéi Targioni-Tozzetti (1867). Stud. sul. Cocciu.

(Plate IV, fig. 1; Plate XV, fig. 1)

Scale of the female.— The scale of the female is flat, whitish, or light gray in color, and with the exuviae central or nearly so (Fig. —). Exuviae dull orange-yellow; the first skin usually showing the segmentation distinctly, the second skin more or less covered with secretion, often appearing only as an orange-colored circle surrounding the first skin. Ventral scale a mere film applied to bark of plant. Diameter of fully formed scale, 2 mm. (.08 inch).

Female.— The body of the adult female is nearly circular in outline, with the abdominal segments forming a pointed projection; light yellow in color, mottled with darker yellow; the last segment presents the following characters:

The anterior lateral groups of *spinnerets* consist each of about nine, and the posterior laterals of about seven.

There are three pairs of *lobes*; the first and second are well developed, the third are quite small.

The *plates* are well developed; they are long and usually fringed; there are two small ones between the median lobes; those of each side are as follows: two between the first and second lobes; three between second and third lobes; and usually seven laterad of the third lobe, of which usually four are fringed and three simple. The number of the last-named group varies from four to nine.

There is on each surface of the segment a *spine* accompanying each lobe; one between the fourth and fifth plates laterad of third lobe, and one at about one-third the distance from this spine to the penultimate segment. In each case the spine on the ventral surface is a little laterad of the one on the dorsal surface.

Egg.— The eggs are very light yellow in color.

Scale of male.— The scale of the male is slightly elongated, with the larval skin nearly central; it is snowy white with the larval skin light yellow; longest diameter, 1 mm. (.04 inch). (Fig. 1*f*.)

Male.— The adult male is yellow mottled with reddish brown, central part of thoracic band reddish. Other characters represented in figure 1*a*.

Habitat.— This is a very common European species which infests many different plants, and it is spread throughout our country from Atlantic to the Pacific, and from the Great Lakes to the Gulf of Mexico. I have found it more abundant on acacias in California than elsewhere, and for a time believed that it had been introduced from Australia with this tree. Many trees were found the leaves of which were completely covered with the scales, appearing as if they had been coated with whitewash. Leaves of magnolia were received from Mr. C. H. Dwinelle, Berkeley, Cal., which were infested to a similar extent. The following is a list of the plants upon which I have studied this species: acacia, magnolia, oleander, maple, yucca, plum, cherry, currant, and Melia (*Melia azederach*) in California; oleander in Utah; English ivy in a conservatory at Ithaca, N. Y.; ivy and "China tree" from Dr. R. S. Turner, Fort George, Fla.; grass and clover growing in pots with orange trees upon which I was rearing the scale at this department; lemons imported from the Mediterranean by a San Francisco dealer; and lemons forwarded to me by Mr. Alex. Craw from the grove of Mr. Wolfkill, at Los Angeles, Cal.

The scales upon magnolia from Berkeley, Cal., and upon oleander from Salt Lake City appear somewhat different from those on acacia and other plants. But after a very careful study of the different forms from each plant, I am unable to point out any character which will distinguish those on magnolia and oleander from others.

Specimens of infested lemons from Europe were forwarded to me at Washington by the editor of the Riverside Press and Horticulturist, who had received them from a correspondent in San Francisco, who had imported them from the Mediterranean. Notwithstanding the great distance (once across the Atlantic and twice across the continent) which this fruit had been transported, the insects infesting it were alive and in a healthy condition. This illustrates the ease with which these insects may spread from one country to another, and the dangers attending the introduction of foreign fruit and nursery stock.

The appearance of this pest upon citrus fruits in southern California is greatly to be regretted, for the species is already so common on other plants that it may be difficult to keep the orange groves free from it. The fact, however, that it infests acacia, oleander, and other plants to such a great extent, and has been observed but few times in this country on citrus fruits, may be taken as an indication that it is not liable to multiply to any great extent upon oranges and lemons.

In the specimens which I have seen the leaves of the lemon were not infested, but the scales were very abundant on the fruit.

The young of this insect which were found on ivy in Florida were colonized on an orange tree in the breeding room of the department. When one day old the larvae had settled and commenced excreting a covering; when four days old this covering was quite dense; on the twentieth day some larvae molted, and on the twenty-eighth day the second molt occurred. It was observed that this molt was accomplished by a splitting of the skin at the sides of the body, so that the dorsal half of the skin became attached to the scale and the ventral half to the leaf. Soon after this molt all the specimens died. This was an indication that this species could not mature upon the orange. But a very careful study of the form from Florida has failed to reveal any character by which it can be separated from that living on lemon in California.

Although I failed to ascertain the time occupied by a single genera-

tion, the following notes indicate that there are at least two each year, and probably more. On the 13th of April, 1880, specimens of magnolia leaves were received from Berkeley, Cal., infested by this insect. The eggs were hatching from this date till 27th April. During this time (22d April) leaves of ivy were received from Florida, upon which were scales and newly hatched young of this species. On the 21st of May other specimens were received from Florida; of these the females were about one-half grown, and the males were in the pupa state.

On the 24th of August I observed again at Los Angeles, Cal., the eggs of this species.

During April adult males emerged in my breeding-cages from both the California (Berkeley) and Florida specimens. And during August the males were again flying at Los Angeles, Cal.

In conservatories there is apparently no regularity in the periods of this insect; for specimens of all stages, from the egg to the adult, may be observed at the same time.

ASPIDIOTUS OBSCURUS, new species

THE OBSCURE SCALE

(Plate XII, fig. 4; Plate XIII, fig. 4)

Scale of female.— The scale of the female is very dark gray, agreeing in color with the bark to which it is attached; and as it is only slightly convex, its presence is difficult to detect. It is somewhat irregular in outline, but nearly circular. The exuviae are between the center and one side; their position is indicated by a nipple-like prominence, which is marked, as in many other species, with a white dot and concentric ring of the same color. The ventral scale consists of a delicate film of white excretion, and the lower half of the exuviae attached to the bark. Diameter of scale, 3 mm. (.12 inch).

Female.— The body of the fully grown female is reniform, being only four-fifths as long as wide, and having the lobes of the penultimate segment extending back nearly as far as the end of the body. The segmentation of the body is very indistinct; the color is a yellowish brown. The last segment presents the following characters (Plate XII, fig. 4):

There are five groups of *spinnerets*; the median consists of about six, the superior lateral of about twelve, and the inferior lateral of about eight. The oval pores opening on the dorsal side of the body are to be seen very distinctly from below.

There are three pairs of well-developed *lobes*. The first lobe of each side is conical, tapering anteriorly, and with the distal margin rounded; there is often a small notch on the lateral side. The distal margins of the second and third lobes are serrate.

The thickened part of the *lateral margin* of the segment becomes narrower anteriorly until near the penultimate segment it is a mere line. It is irregularly notched and is terminated posteriorly by a prominent lobe.

There are seven short club-shaped *thickenings* of the body wall upon each side of the meson. Each thickening is rounded anteriorly and tapers posteriorly. They are situated as follows: one terminating near the lateral margin of the first lobe, one at each side of second lobe, one midway between second and third lobes, one at each side of third lobe, and one near the posterior end of the thickened lateral margin. This one is often obsolete. Those terminating at the median sides of the sec-

ond and third lobes are narrower and shorter, and have their anterior ends directed laterad more than the others. The remaining thickenings are of about the same length as the median lobes.

The *plates* are inconspicuous, and in no case extend as far as the lobes. There is one between the median lobes, one between the first and second lobe of each side, two between the second and third lobes, and two between the third lobe and the posterior end of the thickened lateral margin. The last two are unequally bifid, the other four are simple and truncate.

On the ventral side the first pair of *spines* is obsolete, the second and third pores are situated at the base of the lateral margins of their respective lobes, the fourth pair is just laterad of the lobe of the lateral margin, and a fifth pair is situated about one-third the distance from this lobe to the penultimate segment. On the dorsal side the first pair is also obsolete, each member of the other four pairs is situated in little mesad of the corresponding spine on the ventral surface.

Egg.— The eggs have not been observed, and several specimens of females in the collection indicate that the species is viviparous.

Scale of male.— The scale of the male is oval in outline with the protuberance covering the larval skin near the anterior end. This scale is of the same color as that of the female.

Length, a little more than 1 mm. (.04 inch); breadth nearly ½ mm. (.02 inch).

Habitat.— On the bark of the limbs of willow oak (*Quercus phellos*) at Washington, D. C.

Described from forty females, and very many scales of each sex.

The scale of this species resembles very much that of *Aspidiotus tenebricosus,* which occurs on red maple. That scale, however, is much more convex than this one, and its diameter is only one-half as great.

ASPIDIOTUS PERNICIOSUS, new species

THE PERNICIOUS SCALE

(Plate XII, fig. 7)

Scale of female.— The scale of the female is circular and flat, with the exuviae central, or nearly so. The scale is gray, excepting the central part, that which covers the exuviae, which varies from a pale yellow to a reddish yellow; sometimes the central part is black, resembling the scale of the male, and in some specimens the outer part of the scale is marked by radiating ridges. Diameter, 2 mm. (.08 inch).

Female.— The body of the female is yellowish and almost circular in outline; the segmentation is distinct, though not conspicuous. The last segment presents the following characters:

There are only two pairs of *lobes* visible; the first pair converge at tip, are notched about midway their length on the lateral margin, and often bear a slight notch on the mesal margin near the tip. The second pair are notched once on the lateral margin.

The margin of the ventral surface of the segment is deeply *incised* twice on each side of the meson; once between the bases of the first and second lobes and again laterad of the second lobe. On each side of each of these incisions is a club-shaped thickening of the body wall.

There are two inconspicuous simple *plates* between the median lobes, and on each side two similar plates extending caudad of the first incision, three small plates serrate on their lateral margin caudad of the second incision, and the club-shaped thickenings of the body wall

bounding it, and three wide prolongations of the margin between the third and fourth spines. These prolongations are usually fringed on their distal margin. There are also in some, irregular prolongations of the margin between the fourth spine and the penultimate segment.

The first and second *spines* are situated laterad of the first and second lobes, respectively; the third spine laterad of second incision; and the fourth spine about half the distance from the first lobe to the penultimate segment.

Egg.— The eggs are white.

Scale of male.— The scale of the male is black, and is somewhat elongated when fully formed. The larval skin is covered with secretion; its position is marked by a nipple-like prominence which is between the center and the anterior margin of the scale. The scale of the male is more abundant than that of the female.

Male.— The male has not yet been observed.

Habitat.— On apple, pear, plum, and other trees in Santa Clara County, California.

Described from thirty females, and very many scales of each sex.

I regret that as yet I have been able to study this very important pest but little. From what I have seen of it, I think that it is the most pernicious scale insect known in this country; certainly I never saw another species so abundant as this is in certain orchards which I have visited. It is said to infest all the deciduous fruits grown in California, excepting peach, apricot, and the black tartarean cherry. It attacks the bark of the trunk and limbs as well as the leaves and fruit. I have seen many plum and apple trees upon which all the fruit was so badly infested that it was unmarketable. In other instances I have seen the bark of all of the small limbs completely covered by the scales. In such cases the wood beneath the bark is stained red.

This species is easily destroyed by strong alkaline washes, as is shown by the results of experiments given in the chapter on remedies.

ASPIDIOTUS PERSEAE, new species

THE RED BAY SCALE

(Plate XII, fig. 3; Plate XIII, fig. 3)

Scale of female.— The scale of the female is circular, flat, with the exuviae nearly central and covered with secretion. The outer part of the scale is dark reddish brown; that part covering the exuviae varies from a very dark gray to black. The ventral scale is a very delicate film which adheres to the leaf. The scale of this species closely resembles that of *Aspidiotus ficus* in form in the presence of the nipple-like prominence which indicates the position of the first skin, and in the color of the outer part of the scale. It is, however, smaller, and has the central part darker than the remainder of the scale, instead of lighter as with *A. ficus*. Diameter, 1.5 to 2 mm. (.06 to .08 inch).

Female.— The color of the female is orange. The body is nearly as wide as long. The last segment presents the following characters (Plate XII, fig. 3):

There are four groups of *spinnerets*; the anterior laterals consist of from ten to twelve, and the posterior laterals of about eight.

There are three pairs of well-developed *lobes* present; each lobe is wider than long; the first lobe of each side is the smallest, the third the largest; the second is usually notched; the third is serrate.

The posterior half of the *lateral margin of the segment* appears to be of the same structure as the lobes; it is serrate, and usually more or less deeply notched four or five times.

The body wall is furnished with seven *thickenings* on each side of the meson. These thickenings are long, somewhat club-shaped, the anterior part being enlarged and rounded. There is one terminating at the base of each margin of each lobe. Those ending at the base of the lateral margins of the lobes are much longer than the others. The seventh thickening terminates between the second and third lobes, and is narrow and inconspicuous.

The *plates* are small, inconspicuous, and irregularly toothed. There are two between each pair of lobes and between the third lobe of each side and the posterior lobe of the thickened lateral margin. The plates increase in size from the meson laterad.

On the ventral side there are four pairs of *spines,* there being a spine at the base of the lateral margin of each lobe and one at the anterior end of the thickened part of the lateral margin of the segment. On the dorsal side there are only three pairs of spines, there being none on the first lobes. Those of the second and third lobes are situated near the middle of the bases of the lobes; the third spine is nearly opposite the fourth spine of the ventral surface.

Egg.— The eggs are slender and pointed at one extremity.

Habitat.— Cedar Keys, Fla., on the leaves of red bay (*Persea carolinensis*).

I collected the scales during February, at which time eggs were found under some of them; a male pupa was also observed at that time.

ASPIDIOTUS? PINI, new species

(Plate XV, fig. 2; Plate XVI, fig. 2; Plate XXI, fig. 7)

Scale of female.— The scale of the female is much elongated, with its sides parallel and ends rounded. The exuviae are nearly central, and are covered with secretion. The color of the scale is dark gray, often approaching black, with the margin lighter, and sometimes with a bluish, brownish, or purplish tinge. In many specimens of the fully formed scale the part covering the exuviae is more or less distinct, appearing like a small scale with a light margin superimposed upon a larger scale. Length of scale, 2 to 3 mm. (.08 to .12 inch); width, .4 to 1 mm.

Female.— The last segment of the female presents the following characters (Plate XV, fig. 2, and Plate XVI, fig. 2):

The *spinnerets* are more or less elongated, and are arranged in two groups, which occupy the position of the anterior laterals in other species. Each group consists of from eleven to sixteen spinnerets.

The *lobes* are quite small; the first and second of each side are abruptly narrowed near the distal extremity; the third lobe is notched once or twice. About one-third of the distance from the third lobe to the penultimate segment is a lobe of the lateral margin of the body of about the size of the third lobe.

The *plates* are short and irregular; there are two with distal extremities fringed between the median lobes; two similar to these between first and second lobe of each side; the lateral member of this pair of plates is much wider than the mesal one; between the second and third lobes are usually four plates each with its lateral margin fringed; between the third lobe and the lobe on the lateral margin of the segment are four or five plates similar in form to those between the second and third lobes; two of these plates are usually very small. The segment is narrowed caudad by a succession of notches as shown in figure 2.

The *spines* of the dorsal surface are quite large; there is one laterad of first lobe; one upon the center of each of the second and third lobes, and one upon the lobe of the lateral margin of the body. On the ventral surface the first spine is obsolete; the second, third, and fourth are each laterad of corresponding spines on dorsal surface; of these the second spine is small, the others large.

Scale of male.— The scale of the male resembles very much the central part of the scale of the female; it is somewhat narrower and darker, being almost black, and with a greenish tinge. The larval skin is cephalad of the center of the scale, and is brownish yellow.

Male.— The body of the male is orange yellow; thoracic band brown; eyes dark brown; antennae (excepting basal joint, which is of the same color as body), legs, and stylet dusky (Plate XXI, fig. 7).

Habitat.— Very abundant on the leaves of pitch pine (*Pinus rigida*) at Ithaca, N. Y. I also collected it on the leaves of yellow pine (*Pinus mitis*) at Macon, Ga.

This species differs greatly from all species of Aspidiotus known to me, not only in the characters of the last segment of the female as shown in figure 2, but in the development of the body of the female, as I hope to show at some future time.

ASPIDIOTUS RAPAX, new species

THE GREEDY SCALE INSECT

(Plate XII, fig. 6)

Scale of female.— The scale of the female is very convex, with the exuviae between the center and one side, and covered with secretion. The scale is gray, somewhat transparent, so that it appears yellowish when it covers a living female; the prominence which covers the exuviae is dark brown or black, usually with a central dot and concentric ring which are white. Ventral scale snowy white, usually entire. Diameter $1\frac{1}{2}$ mm. (.06 inch).

Female.— The body of the female is nearly circular in outline, bright yellow in color with more or less translucent blotches. The last segment presents the following characters:

The groups of *spinnerets* are wanting.

Only one pair of well-developed *lobes,* the median, present. These are prominent. Each one is furnished with a notch on each side; the notch on the mesal margin is distad of that on the lateral margin. The second and third pairs of lobes are represented by the minute pointed projections of the margin of the body.

The margin of the ventral surface of the segment is deeply *incised* twice on each side of the meson; once laterad of the first lobe, and again between the rudimentary second and third lobes. The parts of the body wall forming the margin of these incisions are conspicuously thickened.

There are two simple tapering *plates* between the median lobes, two deeply and irregularly toothed or branched plates extending caudad of each incision, one usually simple and tapering plate between the incisions of each side, and two or three of the same character laterad of the second incision.

The first, second, and third pairs of *spines* of each surface are situated near the lateral bases of the first, second, and third lobes respectively; the fourth pair are situated at a little more than one-half the distance from the median lobes to the penultimate segment. In each case the

spine on the ventral surface is but little laterad of the one on the dorsal surface.

Egg.— The eggs and newly hatched larvae are yellow.

Male.— Only dead and shriveled males have been observed.

Habitat.— On the bark of the trunk and limbs as well as the leaves and fruit of various trees and shrubs in California and Florida.

Described from seventy-five females and very many scales.

I have named this the greedy scale insect on account of the great number of plants upon which the species subsists. It also occurs in some localities in great numbers, being very destructive. This is especially the case on *Euonymus japonicus* at Fort George, Fla.; and in California on olive near San Buenaventura, and on mountain laurel (*Umbellularia californica*) at San José I have also found it on the following-named plants in California: almond, quince, fig, willow, eucalyptus, acacia, and locust.

Mr. Elwood Cooper, of Santa Barbara, Cal., who has had some experience with this pest upon his olive trees, says that it is easily kept in check. According to his observations it flourished only upon those trees which are in an unhealthy condition, and as it is chiefly confined to the trunk and limbs it can be removed with a stiff brush and whale-oil soap solution.

ASPIDIOTUS TENEBRICOSUS, new species

THE GLOOMY SCALE

(Plate XII, fig. 5; Plate XIII, fig. 5)

Scale of female.— The scale of the female is very dark gray, agreeing in color with the bark to which it is attached; the protuberance indicating the position of the exuviae is marked with a white dot and concentric ring; in rubbed specimens this protuberance is smooth and black, in all cases the remainder of the surface of the scale is rough. The scale is very convex; the exuviae are usually between the center and one side. The ventral scale is well developed, especially at the margin, where it is much thickened and is dark-colored; the central part is white and adheres to the bark; while the thickened margin is easily removed as a ring. Diameter of scale, 1.5 mm. (.06 inch).

Female.— The female is nearly circular, being but slightly longer than broad; and is of a yellowish brown color. The segmentation of the body is not very distinct. The last segment presents the following characters:

Although forty-three specimens were carefully examined, no *groups of spinnerets* were found.

There are three pairs of well-developed *lobes.* The median lobes are rounded posteriorly, or often with a slight notch on the lateral margin, and taper to a point anteriorly; the second lobe of each side is somewhat triangular in outline, with the lateral edge serrate; the third lobe is larger than either the first or second lobes, triangular in outline, and serrate on lateral margin.

The posterior third of the *lateral margin of the segment* appears to be of the same structure as the lobes, and has five triangular serrate lobes; the posterior one of these is the largest, and is larger than either of the true lobes.

There are seven club-shaped *thickenings* of the body wall upon each side of the meson, which are arranged as follows: One terminating near the lateral margin of the first lobe; this extends anteriorly but a short

distance beyond the lobe. One appearing to be a prolongation of the mesal margin of the second lobe; this extends anteriorly to a point laterad with the anus. One terminating between the second and third lobes; this is linear, inconspicuous, and sometimes obsolete. One terminating at the base of the plates between the second and third lobes, and also one terminating at the base of the plates between the third lobe and the thickened lateral margin; these two are the largest, and extend anteriorly the farthest of all the thickenings. One terminating at the mesal margin of the third lobe, and one at the mesal end of the thickened lateral margin of the segment.

The *plates* between the median lobes and between the first and second lobes of each side are very small and often obsolete; there are two small, irregularly branched plates between the second spine and the third lobe, and also two similar plates between the third spine and the mesal end of the thickened lateral margin.

There are five pairs of *spines* on the ventral surface of the segment, and six on the dorsal. Those at the base of the median lobes are very small; the others are conspicuous. The second and third spines of each surface are situated just laterad of the second and third lobes respectively; in each case the dorsal spine is slightly mesad of that on the ventral surface. The fourth spine of the ventral surface is on the penultimate lobe of the thickened lateral margin. The fifth spine of this surface is near the anterior end of the thickened part of that margin. The fourth and fifth spines of the dorsal surface are in each case mesad of the corresponding spines of the ventral surface. There is also a spine on the dorsal side, very near the penultimate segment.

Egg.— The eggs have not been observed.

Scale of male.— The scale of the male is oval in outline, and of the same color as that of the female; the protuberance covering the larval skin is near the anterior end. The ventral scale is similar to that of the female, except that the margin is not so much thickened.

Male.— Only dead and shriveled males have been observed.

Habitat.— On the bark of the trunk and limbs of red or swamp maple (*Acer rubrum*) at Washington, D. C.

Described from forty-three females, and many scales of each sex.

ASPIDIOTUS UVAE, new species

THE GRAPE SCALE

(Plate XIV, fig. 4; Plate XVI, fig. 1)

Scale of female.— The scale of the female is flat, nearly circular, with the exuviae covered and more or less upon one side. The color of the scale is light yellowish brown, being a little lighter than the dry bark of the vine. The part of the scale covering the exuviae is white, the latter are bright yellow. The ventral scale is thin, white, contains the ventral half of the molted skins, and adheres to the bark; so that when the insect is removed its former position is indicated by a conspicuous white spot. Diameter of scale, 1.6 mm.

Female.— The body of the female is nearly circular, white, with a faint yellowish tinge, and with the margin colorless and more or less transparent. The last abdominal segment presents the following characters (Plate XIV, fig. 4):

There are either four or five *spinnerets*; the anterior group being either present or absent. Nineteen specimens were examined; the anterior group was represented by a single spinneret in three, by two

spinnerets in six, and was wanting in ten. The anterior laterals each consist of from four to nine spinnerets, and the posterior laterals of from three to eight.

Only one pair of *lobes* present; these are prominent, parallel with each other, or nearly so, and abruptly narrowed posteriorly; the mesal constriction is a little distad of the lateral one.

There are two *incisions* of the margin of the ventral surface on each side of the meson, one laterad of the first spine, the other laterad of the second spine. The body wall bounding these incisions is conspicuously thickened.

Caudad of each incision are two *plates,* which are long and serrate on the lateral margin. Between the third and fourth spine of each side are from three to five plates; these are usually simple and equal the spines in length.

There are four pairs of *spines* on the ventral side and three on the dorsal, the first dorsal pair being obsolete. The fourth pairs are about midway between the lobes and penultimate segment.

Scale of male.— The color of the scale of the male is slightly darker than that of the scale of the female; it is elongated, with the exuviae covered, and near one extremity. The layer of excretion covering the exuviae is white. Length of scale, .8 mm.; width, .4 mm.

Habitat.— On grapevines at Vevay, Ind., received from Charles G. Boerner.

This species infests the lower part of the grapevines, from the ground to the shoots of second year's growth. It can doubtless be easily destroyed by washing the vine with a strong solution of soap, using for this purpose a sponge.

Signoret describes* under the name of *Aspidiotus vitis* a species which infests grapes, and which, judging from his description, is very closely allied to this. It differs, however, from *A. uvae* in that the exuviae when they have been rubbed are of a brilliant black; and the last segment of the female does not present the usual groups of pores.

Genus **DIASPIS** Costa

This genus includes species of Diaspinae in which the scale of the female is more or less rounded, with the exuviae at the center or upon the side, and the scale of the male long, white, carinated, and with the larval skin at one extremity. The last segment of the female presents five groups of spinnerets.

This genus closely resembles Aspidiotus in the form of the scale of the female, but it is easily distinguished from that genus by the form of the scale of the male.

DIASPIS CARUELI Targ.-Tozz.

THE JUNIPER SCALE

(Plate V, fig. 2; Plate XV, fig. 3; Plate XXI, fig. 6)

Diaspis carueli Targioni-Tozzetti, Catal. (1868).

Scale of female.— The scale of the female is circular, snowy white, with the exuviae central or nearly so, naked, and yellow. Diameter of scale, 1 to 1.5 mm. (.04 to .06 inch). (Plate V, fig. 2*a*.)

*Annales de la Société Ent. de France, 1876, p. 603.

Female.— The females are yellow, circular in outline, a little elongated posteriorly. The last segment of the body presents the following characters:

The anterior group of *spinnerets* consists of about eight, the anterior laterals of from ten to sixteen, and the posterior laterals of about eight.

There are four *lobes* which are nearly in a straight line, the end of the body being truncate. These lobes are quite small, rounded posteriorly, and are equidistant from each other. The second lobe of each side is deeply incised, but the lateral lobule is very small and in many cases concealed by the margin of the segment.

Each *lateral margin* of the segment is divided into three subequal, more or less distinct lobes; each lobe ends posteriorly in one or two lobules, each of which bears an elongated pore on its dorsal surface.

The *plates* are short and in some cases subtruncate at extremities; they are situated as follows: two between median lobes; two inconspicuous ones lateral of first lobe of each side; two lateral of second lobe; usually one on the anterior part of the first lobe of the lateral margin; one or two near the middle of the second lobe of the lateral margin, and two or three on the third or anterior lobe of the lateral margin.

The *spines* on the dorsal surface are situated as follows: one upon the first lobe near its lateral margin; one on lateral lobule of the second lobe; and one a short distance mesad of the mesal plate of each of the three lobes of the lateral margin. On the ventral surface the spine accompanying the first and second lobes of each side are obsolete. There is one at the base of the plate of the first lobe of the lateral margin; one between the plates of the second lobe, and one near the middle of the third or anterior lobe of the lateral margin.

Scale of male.— The male scale is white and very small, being only 1 mm. (.04 inch) in length; it is elongated, with a prominent median ridge; the larval skin is naked and light yellow in color. (Fig. 2*b*.)

Male.— The color of the body is light orange yellow, with the thoracic band of the same color. The terminal joints of the antennae are enlarged. (For other characters, see Plate XXI, fig. 6.)

Habitat.— This species is very common in Washington, where we have found it infesting the following-named species of juniper and arbor vitae: *Juniperus chinensis, J. rigida, J. oxycedrus, J. japonica, J. communis, J. Reresii, Biota orientalis,* and *Thuya occidentalis.* It was collected by Professor Targioni-Tozzetti near Florence, Italy.

DIASPIS OSTREAEFORMIS (Curtis)

THE PEAR-TREE OYSTER SCALE

(Plate XV, fig. 4)

Aspidiotus ostreaeformis Ruricola, Gardeners' Chronicle, 1843, p. 803.
Aspidiotus circularis Fitch, Annual Report N. Y. State Agr. Soc., 1856, p. 426.

Scale of female.— The scale of the female is circular or broadly oval; it is of a dark ashy gray color, with the margin lighter; sometimes the scales are nearly white. The exuviae are central or nearly so, dark brown, usually naked and glossy. Diameter 1 to 1.4 mm. (.04 to .056 inch).

Female.— The body of the female is rounded, cordate when young; the last segment presents the following characters:

The anterior group of *spinnerets* consists of eight to twelve; the anterior laterals of twelve to thirteen; posterior laterals of eight to fourteen.

The median *lobes* are large and connate, about half their length; each lobe is rounded at its distal extremity, and widened anteriorly, sometimes abruptly. On each side of the median lobes are three slight incisions in the margin of the body, approximately equidistant from each other; the margins of these incisions are thickened, and mesad of each incision there is a rudimentary lobe; there is also usually a fifth rudimentary lobe between the fifth and sixth plates.

All the *plates* excepting the first pair are well developed, thick at the base, simple, tapering, and situated at nearly equal distances throughout the entire free margin of the segment. Laterad of first lobe is a short inconspicuous plate, between which and second lobe is a prolongation of the body wall bearing an elongated pore; second plate between second and third lobes, third plate between third and fourth lobes; between fourth and fifth lobes are two plates; laterad of fifth lobe are three plates, sometimes there is a fourth next to the penultimate segment. On the penultimate segment are three or four plates, and on the antepenultimate, one or two.

The *spines* on the dorsal surface are situated as follows: on each side a short one near the meson on first lobe; a long and conspicuous one laterad of same lobe; third and fourth caudad of first and second incisions; fifth laterad of third incision; and the sixth between the sixth and seventh plates. On the ventral surface the spines are smaller; first and second are obsolete, the third and fourth are laterad of the second and third incisions; and the fifth between the fourth and fifth plates.

Scale of male.— The male scales are of an elongated oval form and much flattened, especially the posterior half; a feeble carina extends along the middle, but the sides are not carinated; the larval skin is of a light brownish yellow color, and is sometimes more than one-third the length of the whole scale; the ventral side is entirely closed, leaving only a narrow transverse slit at the posterior end; the color of the scale is white. Length 6 mm. (.23 inch).

Male.— The male is described by Curtis as being of a bright ochreous color, with the eyes and thoracic band black.

Habitat.— This is a common species on pear and apple in England. Although I do not know of its occurrence in the United States, it will be strange if it is not found here. I am indebted to Mr. Signoret for the specimens from which this description has been prepared.

DIASPIS ROSAE (Sandberg)

THE ROSE SCALE

(Plate V, fig. 1; Plate XVII, fig. 1; Plate XXI, fig. 5)

Aspidiotus rosae Sandberg (1784), Abhand. Priv. Boh., no. 6, p. 317.
Diaspis rosae Signoret, Ann. de la Soc. Ent. de France, 1869, p. 441.

Scale of female.— The scale of the female is circular, snowy white (or, according to Signoret, yellowish white), with the exuviae light yellow, and upon one side; the first skin is naked, the second usually covered with secretion. Diameter 2 to 3 mm. (.08 to .12 inch). (Plate V, fig. 1, natural size; 1*a*, enlarged.)

Female.— The female is elongated, resembling in form a Mytilaspis more than a Diaspis. The head and thorax comprise the larger part of the body. The abdomen is very distinctly segmented, especially upon the sides; each segment presents one or several plates, the two seg-

ments preceding the last a greater number, but usually less than ten. The last segment presents the following characters:

The groups of *spinnerets* are remarkable from the fact that those of each side are often more or less continuous. Signoret states that the anterior group alone is distinct; but in the majority of the specimens which I have studied the lateral groups are more or less distinct. The anterior group consists of about twenty spinnerets; the lateral group are of from twenty-five to thirty-five each. There are three pairs of lobes. The median lobes are large, slightly serrate, approximate at base, and diverging laterally. The second and third lobes of each side are deeply incised; the mesal lobule in each case is the larger.

The *plates* are long, slender, and simple; those nearer the meson are smaller than those farther removed from it; they are situated as follows: one arising from the base of the lateral margin of each of the three lobes of each side; one midway between the meson and the penultimate segment; two to four near the penultimate segment; there are commonly only two in this position, occasionally three, and sometimes four.

The *spines* on the dorsal surface are situated as follows: one very small one on each of the lobes; one on the outer lobule of each of the second and third lobes; one mesad of the fourth plate; and one between the two lateral plates. On the ventral surface there is situated a spine a little mesad of each of the first four dorsal spines.

Scale of male.— The scale of the male resembles that of other species of Diaspis in being long, tricarinated, white, and with the larval skin at one end. Length 1.25 mm. (.05 inch).

Male.— "The male is of a reddish white, with the wings white, the veins of the wings rosy; the venter is a little darker; the style equals the abdomen in length. Antennae and feet yellowish, slightly pubescent." (Signoret.)

Specimens which we bred were bright orange, with the band of the same color, and the eyes black.

Habitat.— This species infests the bark of rosebushes, and is very widely distributed both in Europe and this country. I have collected it in Florida and California, as well as in the Northern States.

From scales collected in Orange County, Florida, the adult males issued in large numbers February 22. At this date some of the females were ovipositing, and many eggs were hatching.

I have also found this species infesting raspberries and blackberries.

Genus **CHIONASPIS** Signoret

This genus includes species of Diaspinae in which the scale of the female is long, sometimes much widened, with the exuviae at one extremity; and the scale of the male long, generally white, more or less carinated (except in *C. ortholobis*), with the sides parallel, and the larval skin at the anterior end. The last segment of the female presents five groups of spinnerets.

This genus resembles Diaspis in the form of the scale of the male and Mytilaspis in the form of the scale of the female; in most species, however, the scale of the female is wider than in Mytilaspis.

CHIONASPIS EUONYMI, new species

(Plate V, fig. 3; Plate XVII, fig. 2)

Scale of female.— The scale of the female is of a dirty blackish brown color, with a gray margin; the first skin is light yellow, the second is

darker, and sometimes is but little lighter than the scale, which is not as delicate in texture as is usual in this genus; the scale is narrow at the anterior end, and begins to widen at about the middle of the second skin and widens rapidly, so that frequently that part posterior to this skin is wider than long. There is a well-developed ventral scale consisting of a single piece, the margin of which, when it is fully formed, completely coincides with that of the dorsal scale, thus inclosing the insect in a complete shell; the two scales are attached by their lateral margins; the posterior margin, however, is free. Length of scale, 1.64 mm. (.06 inch). Width in widest part, 1.23 mm. (.045 inch).

Female.— The body of the female is bright orange-yellow in color; the segments are very well defined; the fifth segment is the broadest; from this segment the insect tapers slowly to the anterior end of the body, and abruptly to the posterior end.

The last segment presents the following characters:

The anterior group of *spinnerets* consists of from four to six; the anterior laterals, five to eight; and the posterior laterals, two to seven, usually four.

The *lobes* are small and finely serrate; the median lobes diverge posteriorly; the second and third lobes of each side are deeply incised, each being divided into two unequal lobules, the larger of which is mesad. Mesad of each of the second and third lobes is a lobe of the unthickened body wall, which bears an elongated pore on its dorsal surface. In many cases the lateral margins of the segment are notched regularly, and each lobe thus formed bears an elongated pore on its dorsal surface.

The *plates* are slender, simple, and tapering; those on the lateral margin of the segment are the largest. There are two plates laterad of each of the first, second, and third lobes, and a pair about midway between the third lobe and the penultimate segment; sometimes in the case of this group of plates and of that laterad of the third lobe there are three of four plates instead of a single pair. The three segments preceding the last bear several (usually five or more) plates on the lateral margins. The penultimate and last segments are connate at the margin of the body.

The *spines* on the ventral surface of the segment are short and inconspicuous; there is one near the mesal member of each of the first, second, third, and fourth groups of plates. The spines on the dorsal surface are quite conspicuous with the exception of the first, which is very slender; it is situated laterad of the base of the first lobe, which it approximates in length; each of the second and third spines is near the base of the incision which divides the corresponding lobes; the fourth spine is mesad of the fourth group of plates.

Scale of male.— The scale of the male is white, tricarinate, with the exuviae light yellow. Length 1.4 mm. (.05 to .06 inch).

Habitat.— On *Euonymus latifolia* at Norfolk, Va. The specimens were received from Mr. Henry P. Worcester, who informs me that this insect has destroyed nearly all of the shrubs of this species in that city. From the account given by Mr. Worcester it appears that only a short time elapses after the plant becomes infested before it is destroyed; but he has not observed this scale insect upon any other plant than euonymus. It was, however, collected in great numbers, by Mr. Howard, upon orange trees in Louisiana, and I have received it from Havana, from which place it may have been imported to this country.

CHIONASPIS FURFURUS (Fitch)

THE SCURFY BARK LOUSE

(Plate VI, fig. 1; Plate XVI, fig. 3; Plate XVII, fig. 3)

"Approaches *Coccus cryptogamus* Dalman." Harris, Insects injurious to vegetation, 1841, p. 203 (Flint ed., p. 254).
Aspidiotus furfurus Fitch, Report N. Y. State Agr. Soc., 1856, p. 352.
Aspidiotus cerasi Fitch, Report N. Y. State Agr. Soc., 1856, p. 368.
Coccus Harrisii Walsh, Practical Entomologist, vol. ii, p. 31, 1866.
Aspidiotus Harrisii Walsh, Report of the Acting State Entomologist of Illinois, p. 53 (1868).
Diaspis Harrisii Walsh, Signoret, Annales de la Société Entomologique de France, 1876, p. 604.

Scale of female.— The scale of the female is flat, irregular in outline, many bending abruptly to the right or left immediately posterior to the second larval skin, others straight; in all the scale suddenly widens near the posterior end of the second larval skin, thus presenting the form characteristic of the genus; length, 2 to 3 mm. (.08 to .12 inch); color grayish white with the first skin light gray and second skin usually brown, sometimes dark gray.

Described from many isolated individuals occurring on smooth bark of a small branch (Fig. 1). On the rough bark of the trunk the scales are much more irregular in form, and are so massed as to appear like a layer of dandruff.

Female.— The body of the female is red, with the last segment light yellow; this segment presents the following characters:

The anterior group of *spinnerets* consists of from eight to thirteen, usually ten; the anterior laterals are from twenty to thirty; and the posterior laterals are from eighteen to thirty-one.

There are three pairs of *lobes.* The median lobes are well developed; the second lobes are smaller, the third are still smaller, being sometimes obsolete; the lobes of the second and third pairs are deeply incised. There are conspicuous elongated pores upon the margin; one laterad of each of the first, second, third, and fourth plates; one cephalad of the incision of the third lobe; and one midway between the third and fourth plates.

The *spines* upon the ventral surface are inconspicuous; the first pair obsolete; the second, third, and fourth pairs at or near the bases of the second, third, and fourth plates. Those upon the dorsal surface are quite long; the first spine of each side is between the bases of the first lobe and the first plate; the second and third spines are upon the lateral lobule of the second and third lobes; and the fourth spine is situated about two-thirds distance from the third to the fourth plates.

Egg.— The eggs are purplish red.

Scale of male.— The scale of the male is very small, being only .75 mm. (.03 inch) in length, narrow, usually straight and tricarinated (Fig. 1*a*); larval skin brownish yellow, remainder of scale snowy white.

Male.— Yellow marked with irregular reddish brown spots; thoracic band reddish brown, sometimes darker than the other markings. Length of body including style, .62 mm. (.02 inch); length of style, .18 mm. (.006 inch). On each side of the anterior part of the thorax there is a black spot which resembles an eye. Other characters represented in figure —.

Habitat.— Harris described it on apple and pear in Massachusetts;

Dr. Fitch found it on pear and chokecherry in New York; Walsh observed it on apple, crab, and the European mountain ash (*Sorbus aucuparia*) in Illinois; and I have found it common in apple and pear in New York, Maryland, and southern California, and upon black cherry in western New York.

Although this insect has been well known for many years, comparatively little has been written respecting it. This is probably due to the fact that there is another species (*Mytilaspis pomorum* Bouché), which, like this, infests the apple, and which is more common and much more destructive. The scurfy bark louse was first described, but not named, by Harris in his *Insects Injurious to Vegetation* (Flint edition, p. 254). In this description both the scale formed by the male and that formed by the female are well characterized; but the insects themselves were not studied by Dr. Harris. The description of the scales is remarkable as containing an explanation of their nature and probable mode of formation as follows: "The minute oval dark-colored scales on one of the ends of these white cases are the skins of the lice while they were in the young or larva state, and the white shells are probably formed in the same way as the down which exudes from the bodies of other bark lice, but which in these assume a regular shape, varying according to the sex and becoming membranous after it is formed." This statement must have been overlooked by Dr. Fitch, who many years afterwards, in his first report as State Entomologist of New York, p. 739 (35), in writing of the oyster-shell bark louse of the apple, states that "these scales are the relics of the bodies of the gravid females, covering and protecting their eggs." And in his second report, p. 489 (257), Dr. Fitch, in describing the pine-leaf scale (*Mytilaspis pinifoliae*) states that the three parts of the scale represent seemingly the head, thorax, and abdomen of the living insect.

Through the kindness of Mr. Lintner and the officers of the New York State Agricultural Society I have had the opportunity of studying the Coccidae in the collection of that society. The specimens were all labeled by Dr. Fitch, and by a very careful study of both the scale and the last segment of the female, of the specimen labeled *Aspidiotus cerasi*, I have been unable to find any character which will separate it from the specimens labeled *Aspidiotus furfurus*, and all of these specimens belong to the same species as the very common pest of the apple and pear, which has been commonly known as *Aspidiotus Harrisii*.

The statement made by Signoret* that this species is the same as that described by Curtis under the name of *Aspidiotus* (*Diaspis*) *ostreaeformis* is evidently a mistake. M. Signoret has kindly sent me specimens of *D. ostreaeformis*, from which I have prepared the description of that species in this report.

CHIONASPIS NYSSAE, new species

THE SOUR-GUM SCALE

(Plate XVII, fig. 4)

Scale of the female.— The scale of the female is snowy white, with the exuviae yellowish. It is flat, quite delicate in texture, and varies greatly in shape; it widens suddenly near the posterior end of the second skin, often becoming as wide as long; some specimens are straight, others are bent to the right or left. Length 1.5 mm. (.05 inch).

*Annales de la Société Entom. de France, 1876, p. 604.

Female.— The last segment of the body presents the following characters:

The anterior group of *spinnerets* consists of six to eight; the anterior laterals of ten to twelve; posterior laterals eight to twelve.

The median *lobes* are large, oblong, joined at the proximal end, and widely separated at their distal extremities; the lateral margins are joined to the body, the mesal margins serrate. The second lobe of each side is incised near its lateral end, the mesal lobule being three times as large as the lateral; third lobe being obsolete.

There are four long simple *plates;* the first and second are laterad of the first and second lobes and are much longer than the lobes; the third plate is midway between the median lobe and the penultimate segment; and the fourth is near the penultimate segment.

The *spines* on the ventral surface are arranged as follows: first pair obsolete; the second, third, and fourth pairs mesad of the bases of the second, third, and fourth plates. The spines upon the dorsal surface are long and conspicuous; there are four pairs, there being a spine mesad of each plate.

Egg.— The eggs are greenish yellow, with purplish markings.

Scale of the male.— The scale of the male is of the form characteristic of the genus, snowy white, with carinae prominent; it is relatively very long, measuring 1.25 mm. (.05 inch).

Male.— The male is greenish yellow, with the thorax and especially the thoracic band darker; eyes purplish.

Habitat.— On the black or sour gum (*Nyssa multiflora*), at Bakersville, N. C. Both male and female occur upon the leaves of the tree.

Described from eight females, thirty scales of the female, four males, and many scales of the male. I am indebted to Dr. R. S. Turner for the specimens.

CHIONASPIS ORTHOLOBIS, new species

(Plate XVI, fig. 6; Plate XIX, fig. 1)

Scale of female.— The scale of the female very closely resembles that of *C. salicis*; it is, however, smaller and narrower. Length, 2 to 2.5 mm. (about .08 inch).

Female.— The body of the female is dark purple; the last segment presents the following characters:

The anterior groups of *spinnerets* consist of from ten to sixteen; the anterior laterals of eighteen to thirty; and the posterior laterals of sixteen to twenty.

The median *lobes* are almost contiguous; their mesal margins are parallel for more than half their length; the distal margin of each is rounded.

Each of the second and third lobes is deeply *incised*; the lateral lobule in each case is very small, often obsolete; the mesal lobule is large and rounded; the distal margins of all the lobes are obscurely crenate.

The *plates* are as follows: one laterad of first lobe; one or two laterad of second lobe; two laterad of third lobe; and two quite large ones quite near the penultimate segment. The penultimate segment usually bears four, and the antepenultimate one.

The *spines* on the dorsal surface are as follows: the first on the base of the lateral part of first lobe; the second and third on the lateral lobule of the second and third lobes, respectively, and the fourth a short distance mesad of the lateral pair of plates. On the ventral surface there are also four on each side; each spine is laterad of the correspond-

ing spine of the dorsal surface, and cephalad of the base of the corresponding plate or group of plates.

Egg.— The eggs are dark purple.

Scale of male.— The scale of the male differs from all other specimens of this genus known to me in not being carinated. It is an elongated oval in outline, being slightly broadest at the middle, and tapering towards both ends almost equally. The larval skin is light yellow; the scale is snowy white.

Described from thirteen males, and many scales of each sex.

Habitat.— On willow, at San Bernardino, Cal. This species infests chiefly the bark of the small whip-like limbs which spring from the trunks of the trees. Many of these sprouts were dead and white with the scales of this species.

The eggs were observed September 12.

CHIONASPIS PINIFOLIAE (Fitch)

THE PINE-LEAF SCALE INSECT

(Plate VI, fig. 2; Plate XVI, fig. 4; Plate XVIII, fig. 1)

Aspidiotus pinifoliae Fitch. Report N. Y. State Agr. Soc., 1855. p. 488.
Mytilaspis pinifoliae Fitch. Le Baron, First Report State Entomologist of Illinois, p. 83.

Scale of female.— The scale of the female is snowy white in color, with the exuviae light yellow; it is usually long and narrow as represented at figure 2*b*; sometimes, however, it is broad, as represented at figure 2*c*. (Scale from leaf of *Pinus pallasiana.*) The shape of the scale apparently depends on that of the leaf to which it is attached. Thus on the broader-leaved pines the broad scales are more common.

Length of scale, about 3 mm. (.1 inch).

Female.— The body of the female is purplish red; the last segment presents the following characters:

The anterior group of *spinnerets* consists of from seven to ten; the anterior laterals of twelve to twenty; and the posterior laterals of fourteen to eighteen.

The median *lobes* are somewhat circular in outline with their distal ends diverging slightly; there is an arched thickening of the body wall connecting the anterior ends of the lobes. The second and third lobes are each deeply incised; the mesal lobule is in each case the larger.

The *plates* are long, simple, tapering to a point, there is one laterad of each of the three lobes of each side, and one midway between the third lobe and the penultimate segment. There are elongated marginal pores in the following situations: One laterad of each of the first and second plates; one at the base of the mesal lobule of the third lobe; two between third and fourth plates; and two between the fourth plate and the penultimate segment.

The *spines* on the ventral surface are so delicate as to be almost invisible; their bases, however, are easily seen; they are situated one mesad of the base of each of the first, second, third, and fourth plates. The spines on the dorsal surface are quite long; the first is near the base of the first lobe, the second between the lobules of the second lobe, the third on lateral lobule of third lobe, and the fourth a short distance mesad of the fourth plate.

Scale of male.— The scale of the male is white and carinated as with other species of this genus. (Plate VI, fig. 2*d*.)

Male.— The male is a uniform orange-red; eyes black.

Habitat.— On various species of pine and spruce throughout the eastern United States from New York to Florida, also pine in California.

CHIONASPIS QUERCUS, new species

(Plate XVIII, fig. 2)

Scale of female.—The scale of the female is long, narrow at the anterior end, much widened posteriorly, and quite convex. The exuviae are brownish yellow; the secretion, of which the remainder of the scale is composed, is white; but all of my specimens appear dark gray, being more or less covered with the hairs of the stem to which the scale was attached and with dust. Length of scale, 2 mm. (.08 inch).

Female.— The last segment of the female presents the following characters:

The anterior group of *spinnerets* consists of about ten; the anterior laterals of seventeen to twenty; and the posterior laterals of ten to eighteen.

This species differs from all Diaspinae known to me in having a single undivided *lobe* on the meson; this lobe is large and rounded distally. The second and third lobes of each side are very small and are laterad of small incisions in the margin of the segment. In each case there is a reniform thickening of the body wall bounding each incision anteriorly. There is also a similar incision with a rudimentary lobe and reniform thickening of the body wall about midway between third lobe and penultimate segment.

The *plates* are inconspicuous and spine-like; there are usually one or two laterad of second ventral spine; two or three between third and fourth lobe and usually five between fourth lobe and penultimate segment. The penultimate and antepenultimate segments bear six each; those on the latter are much expanded at the base.

The *spines* are long and conspicuous; those on the dorsal surface are situated as follows: one on each side at the base of the lateral margin of median lobe, one laterad of each of the second and third lobes, and a fourth one near the center of the anterior group of plates. Those on the ventral surface are as follows: a short one nearly ventrad of the first dorsal spine, a large one laterad of each of the second and third dorsal spines, and a fourth one a little cephalad of the fourth dorsal spine.

Scale of the male.— The scale of the male is snowy white, with the larval skin very light yellow. The texture of the scale is quite loose and the carinae prominent; length 1.25 mm. (.05 inch).

Male.— The adult male is as yet unknown; many pupae were collected August 17, 1880. Specimens of these mounted in balsam are bright yellow in color, with eyes purplish black. Fully grown male larvae in balsam are yellowish brown.

Habitat.— On white oak (*Quercus lobata*) in San Fernando Valley, California. The females occur on the bark of the small limbs; the males upon the leaves.

Described from four scales of the female, four females, hundreds of scales of the male, and many male pupae and larvae.

CHIONASPIS SALICIS (Linn.)

THE WILLOW SCALE

(Plate XVI, fig. 5)

Coccus salicis Linn. Syst. Nat., 741, 15.
Chionaspis salicis Signoret. Ann. de la Soc. Ent. de France, 1869, p. 447.
Chionaspis fraxini. Signoret, l. c., p. 445.
Aspidiotus salicis-nigrae Walsh. Report Acting State Entomologist, Illinois (1868), p. 40.
Mytilaspis salicis Le Baron. Second Annual Report State Entomologist, Illinois (1872), p. 140.

Scale of female.— The scale of the female is of the form characteristic of the genus, being long, narrow at the anterior end, and broadly widened posteriorly. Exuviae dark yellow, normally covered by a thin layer of white excretion; this, however, is easily removed. Scale snowy white. Length 3.4 mm. (.13 inch); width near posterior end, 1.6 mm. (.06 inch).

Female.— The body of the female is reddish. The last segment (Plate XVI, fig. 5) differs from that of *C. ortholobis* as follows: the median lobes are joined at the base, and are widely separated at their distal extremities; between the first plate and the second lobe and mesad of the third lobe are prolongations of the body wall, which extend caudad as far as the lobes, and bear elongated pores. Immediately laterad of the third group of plates is a prominent prolongation of the body bearing an elongated pore, while in the case of *C. ortholobis* this is situated at one-third the distance from the third to the fourth group of plates. In *C. salicis* the two lateral groups of plates often consist of three instead of two, and the penultimate segment bears at least six plates, the antepenultimate three or four, and the one anterior to this, one or two.

Scale of male.— The scale of the male is long, narrow, with the sides nearly parallel. It is tricarinated and snowy white, with the exuviae yellowish.

Habitat.— Infesting willow and ash in Europe and in the United States.

Specimens of "*Chionaspis fraxini*" received from England are identical with *Chionaspis salicis* received from M. Signoret. I have also received this species from Ithaca, N. Y., and from Saint Louis, Mo., in each case upon willow.

Genus **MYTILASPIS** (Targ.-Tozz.)

This genus includes the species of Diaspinae in which the scale is long, narrow, more or less curved, and with the exuviae at the anterior extremity. The scale of the male resembles that of the female in form; but it can be readily distinguished by its small size, and by bearing only one larval skin.

In all the species of Mytilaspis which I have studied the posterior part (about one-fourth) of the scale of the male is joined to the remainder by a thin portion which serves as a hinge, allowing the posterior part to be lifted when the male emerges.

MYTILASPIS CITRICOLA (Packard)

(Plate VII, fig. 1; Plate XX, fig. 3; Plate XVIII, fig. 3)

Aspidiotus citricola Packard. Guide to the study of insects, second edition (1870), p. 527.*

Scale of female.— The scale of the female is long, more or less curved, and widened posteriorly. It is brown with the exuviae of the same color and with a delicate margin (Fig. 1*a*). The ventral scale is well developed; it is white, and consists of a single piece which is slightly attached at its sides to the lower edge of the scale, and is more or less incomplete posteriorly (Fig. 1*b*). Length of scale, 3 mm. (.12 inch).

Female.— The female is yellowish white. The characters of the last segment are as follows:

The anterior group of *spinnerets* consists of about six; the anterior laterals of about eighteen, and the posterior laterals of about nine.

The median *lobes* are well developed with the margins crenate; the second lobe deeply incised, with the margins of the lobules either entire or crenate; the third lobe is quite inconspicuous, projecting but little beyond the body wall, the margin crenate and one large notch in the center of the lobe.

The *plates* are long, simple, and tapering. There are two of them in each of the following places: between median lobes; between first and second lobes; between second and third lobes; laterad of third lobe; and about midway between this lobe and the penultimate segment. There is an elongated pore between first and second lobes; two laterad of each of the third and fourth pairs of plates; and one laterad of the fifth pair of plates. The penultimate segment bears at least four plates upon each lateral margin.

The *spines* upon the dorsal surface are long, and are situated as follows: one at the base of each margin of the first lobe; one dorsad of incision of second lobe; one dorsad of the notch of third lobe; and one about midway between the fourth and fifth pairs of plates. Those of the ventral surface are as follows: cephalad of the bases of the first pair of plates are two small spots which resemble the bases of spines, and are doubtless the homologues of the first pair; the second spine of each side is near the base of the lateral half of the first lobe; third spine laterad of lateral lobule of second lobe and fourth and fifth spines between the members of the fourth and fifth pairs of plates respectively.

Egg.— The eggs are white and are arranged irregularly under the scale.

Scale of male.— The scale of the male is usually straight, or nearly so; the same col r as that of the female, or in some specimens varying to a very dark brown, almost black, the larval skin light yellow. At about one-quarter of the length of the scale from the posterior extremity, the scale is thin, forming a hinge which allows the posterior part of it to be lifted by the male as he emerges. Length 1.5 mm. (.06 inch).

* The descriptions of *Aspidiotus Gloverii* and of *Aspidiotus citricola* given by Packard in his *Guide to the Study of Insects*, p. 527, are not only unrecognizable *per se*, but are merely descriptions of unpublished figures, and consequently have no claim to recognition. But a desire to prevent confusion has led me to adopt these specific names. I have had no hesitation in doing this, because a very careful search which I have made of many orange groves in Florida has revealed the fact that there are only two species of Mytilaspis common on citrus trees in that State, and consequently there can be but little doubt that they are the species which Professor Glover figured. To the form with the narrower scale I apply the name *Gloverii*, to the other that of *citricola*.

Development of the insect and formation of the scale.— Upon March 15, 1880, observations were commenced upon a brood of young lice just hatching. Their color was white, yellowish at both ends, and with red eyes; antennae 6-jointed; margin of the head as far as the eyes tubercled, and each segment of the abdomen with a lateral piliferous tubercle. When placed upon a young orange tree, all settled in from fifteen to twenty minutes. Twenty-four hours later no change had taken place except that the cottony excretion referred to in the general remarks was already observable at the posterior end of the body. Forty-eight hours from the time of hatching the cottony mass had increased to such an extent that only the anterior fourth of the larva could be seen. The secretion was dense and compact, and a few long, very fine, rather curly threads of a yellowish color protruded from it. Each side of the head a fine curl of the cottony substance extended forward and, from the frontal border of the head, filaments of the same extended at equal distances. At seventy-two hours the dense excretion had covered the eyes. Behind the head in most specimens there was a marked constriction in the covering, which in some, however, was but slightly indicated.

From this period up to the age of ten days the alteration was but slight. The covering had increased so as to extend beyond the head of the insect. Removing the covering, it was noticed that nearly all trace of the segmentation of the abdomen was gone, and that it was oval in form. Upon abdominal joints 1, 2, 3, and 4, four rows (two dorsal and two lateral) of pale transparent spots were noticed. From this time (March 25) on until April 6, the changes in the body of the insect were very slight. The skin was gradually separating from the body within, and toward the latter part of this period the abdominal outline of the latter with its notches could be plainly seen through the first larval skin. April 6, or twenty-two days from hatching, the larvae molted their first skin. In preparation for this act they worked their way partly out of their excreted cases, sometimes destroying the anterior end in the effort. In the act of molting the skin splits ventro-transversely between the thorax and the abdomen, and the abdomen is first drawn forward and thrust through the aperture. How the remainder of the body is disengaged is not precisely known — whether it is drawn down through the same split, or whether the anterior part of the old skin has a longitudinal ventral split — but the latter is probably the case. The color of the insect after this first molt is white with pale orange eyes and a tinge of yellow to the proboscis, to the alimentary canal, and to the end of the body. Great irregularity was noticed in the time of shedding of the skin, some finishing two weeks before others, and after the molt was completed some were covered entirely and hidden from view by the cast-off skin and waxy secretion; while others were partly exposed. The old covering began to melt gradually and the new scale began to form at the posterior end of the body, at first resembling compact scum or froth, and six days after the molt it was already from three to four times the size of the shed skin which adheres to the outside of the forming scale, covered as to its anterior half by the remains of the woolly secretion of first stage.

From this time on till forty days from the time of hatching the scale grew gradually as also the inclosed insect, the former at this time changing from white to yellowish brown, having precisely the appearance of the full-grown scale except as to size. At forty-four days after hatching, the scales were about one-fourth the size of the full-grown. At forty-six days it was observed that the male larvae were rapidly maturing and that already traces of antennae and legs were to be seen. At fifty-four

days the more advanced individuals shed the second skin and appeared as pupae. About the same time the females also cast their second skin. Our notes do not show the exact length of time which the males remained in the pupa state, but that it is very short is shown by the fact that on May 18 pupae from eggs hatched March 30 were observed to transform to adults, the old pupa skin being pushed backward out of the scale. The description of the adults of both sexes has already been given.

At eighty days the females were observed to have deposited eggs and already the young had begun to hatch. Later in the season the development is more rapid than that just detailed. From eggs which hatched May 22, males were reared June 25, a space of thirty-four days, while the females of the same generation had begun to oviposit July 12, or fifty-one days from hatching.

Habitat.— This is one of the two most common species of scale insects found on citrus trees in Florida. It is probably an European species, as I have frequently found it on imported oranges in our market. It also occurs in Louisiana. Mr. Glover states (Report Department of Agriculture, 1855, p. 119) that this species was imported into Jacksonville, Fla., in 1855, on some lemons sent from Bermuda.

MYTILASPIS GLOVERII (Packard)

GLOVER'S SCALE

(Plate VII, fig. 2; Plate XVIII, fig. 4; Plate XXI, fig. 1)

Coccus Gloverii (Packard). Guide to the study of insects (1869). p. 527.
Aspidiotus Gloverii (Packard). Ibid., second edition (1870). p. 527.
Mytilaspis Gloverii (Packard). Ashmead, Orange insects (1880), p. 1.

Scale of female.— The scale of the female in this species differs from that of *M. citricola,* with which it is often associated, in being much narrower (Plate VII, fig. 2, natural size; 2*a*, enlarged). Color light yellow, varying to dark brown; the ventral scale is white and consists of two long narrow parallel plates between which is an open space (Plate VII, fig. 2*c*.)

Female.— The body of the female is light purple in color, with the last segment yellowish; this segment presents the following characters:

The anterior group of *spinnerets* consists of five; the anterior laterals about eleven, and the posterior laterals of five.

The *margin of the segment* is the same as in *M. citricola* with the following exceptions: the first lobe on each side is abruptly narrow, then prolonged more or less into a point, with the margins scarcely serrate; lobules of second lobe longer and narrower.

The *spines* are very small; the ventral one on the median lobe invisible. There are only two plates on the penultimate segment.

Egg.— The eggs are white when first laid, but become tinged with purple before hatching. They are arranged in two rows in a very regular manner. (Plate VII, fig. 2*c*.)

Scale of male.— The scale of the male is similar in form to that of the female, except that there is but a single molted skin, and the scale is furnished with a hinge like that described under head of *M. citricola.*

Male.— For figure of male see Plate XXI, figure 1.

Development of the insect and formation of the scale.—Our observations show that the development of Glover's scale is up to a certain point almost parallel with that of *M. citricola,* and that its failure at that point may be abnormal will be seen from what follows. March 27, eggs under

observation began to hatch. The young larvae are purplish, with the front of the head and the margin of the body yellowish. Most of them settled almost immediately, and at two days the cottony excretion had covered one-half the insect. At four days it reached beyond the eyes, and the larva itself seemed to be more elongated, with the joints more distinct. At six days most of them were entirely covered, with the excretion extending like two horns at each side of the head. With some there were only two or three transverse constrictions of the covering, giving them a very peculiar appearance. At seven days the future dentate appearance of the abdomen could already be detected through the skin, and at eleven several presented every appearance of a speedy molt, having pushed themselves forward from the covering. They remained in this state, however, without marked change, except that some secreted a tuft of the waxy threads, which rose erect for two or three times the length of the scale, for twelve days more before shedding their first skin, which was done at the age of twenty-three days. The molt was performed in precisely the same manner as with *M. citricola.* Immediately after the molt the whitish permanent scale began to form. At thirty-two days one could begin to distinguish the legs and antennae of the future pupae in the males. At forty-four days the first female was observed to have cast its second skin; the color after the molt is white, with the anal segment and middle of the body yellowish. About the same time the males became pupae, and at forty-five days the first adult male was found. From this time up to the age of one hundred and two days the female scales were watched daily, but no eggs were observed. At this age all either died or were mounted, so the age at which the eggs are deposited has not been determined. It may be that the non-development in this case was due to the fact that the females had not been fertilized.

Habitat.— This is a very common species on citrus trees in Florida and Louisiana. It infests the fruit, leaves, and bark of the trees, and is usually associated with *M. citricola.* It is supposed that it was introduced into Florida about forty years ago by Mr. H. B. Robinson, who owned a grove at Mandarin. Mr. Robinson is said to have purchased two trees in New York from a ship from China. From these trees the insect is said to have spread.*

Trees which this department received from Europe were badly infested by this scale insect. This, however, does not prove the European origin of the pest, as it may have been carried there from China.

MYTILASPIS? PANDANNI, new species

(Plate XX, figs. 1 and 2)

Scale of female.— The scale of the female is light brown in color, with the posterior end paler and sometimes white; the first larval skin is naked; the second, which is large, is covered with excretion. The shape varies greatly. Some specimens broaden gradually from the first larval skin to near the posterior end; in some the lateral margins are more or less curved, so that the scale is broadest at or near the middle; others are suddenly widened near the middle of the second larval skin.

Females.— The body of the female is yellowish; the last segment presents the following characters:

The anterior group of *spinnerets* consists of four; the anterior laterals of nine or ten; the posterior laterals of ten to twelve.

*See Glover, Report Department of Agriculture, 1855, p. 117.

There are two pairs of *lobes*; each lobe is small; the mesal margins of the median lobes are parallel; between these lobes is an incision extending cephalad of base of lobes for a distance equal to one-half of length of lobes. The second lobe of each side is deeply incised; the mesal lobule is the largest and longest.

The *plates* are simple, tapering, and longer than the lobes. There is one laterad of each of the lobes; one a little less than half the distance from the first lobe to penultimate segment; and one near the latter. The penultimate segment usually bears two and the antepenultimate one.

The *spines* on the dorsal surface are quite long, and are situated as follows: first, laterad of first lobe; second, upon the lateral lobule of second lobe; third, at about two-thirds the distance from second to third plates; and fourth, at two-thirds the distance from third plate to fourth plate.

Between the first plate and mesal lobule of second lobe is a *projection* of the body as long as the latter, which bears an elongated pore.

Described from fourteen females and many scales.

Habitat.— This species was collected by Mr. Trelease, upon Pandannis, in the Harvard Botanic Garden, at Cambridge, Mass.

The scale of this insect varies greatly from the typical form of Mytilaspis. The species is evidently closely allied to the *M.*(?) *buxi* (Bouché) as described by Signoret.

MYTILASPIS POMORUM (Bouché)

THE OYSTER-SHELL BARK LOUSE OF THE APPLE

(Plate XIX, fig. 2)

Aspidiotus pomorum Bouché. Ent. Zeitung Stett. (1851), XII, no. 1.
Aspidiotus conchiformis of authors; but not *A. conchiformis* Gmélin, Syst. Nat., 2221, 37 (1788), which species infests elm.
Aspidiotus pyrus-malus Rob. Kennicot (1854), Acad. Science of Cleveland.
Mytilaspis pomicorticis Riley. Fifth Report State Entomologist, Missouri, p. 95.
Mytilaspis pomorum (Bouché). Signoret, Ann. de la Soc. Ent. de France, 1870, p. 98.

Scale of female.— The scale of the female is long, narrow, widened posteriorly, more or less curved, of an ash gray color with the exuviae yellowish. Length, 2 mm. (.08 inch).

Female.— The body of the female is yellowish white. The last segment presents the following characters:

The anterior group of *spinnerets* consists of from eleven to seventeen; the anterior laterals and posterior laterals each of sixteen to twenty-one.

The median *lobes* are large and wide, with the sides parallel; they are only about three-fourths as long as broad; each lobe is narrowed on each side near the distal extremity by one or two notches and then rounded. The second lobe of each side is about as wide as the first, and is deeply incised; mesal lobule with mesal margin as long as lateral margin of the first lobe, and rounded posteriorly; lateral lobule about half the length and width of mesal lobule and similar in shape. Third lobe obsolete.

The *plates* are arranged as in *M. citricola*; the lateral members of the second and third pairs are shorter and smaller than the mesal. The penultimate segment bears two pairs on each side.

The *spines* are as in *M. citricola* except that the first dorsal pair are not so conspicuous.

Scale of male.— The scale of the male of this species closely resembles those of *M. Gloverii* and *M. citricola,* being much smaller than that of

the female, straight or nearly so, with a single molted skin, and with the posterior part joined to the remainder of the scale by a thin portion which serves as a hinge.

Male.— I have not bred the male from apple. Its color is described by Riley* as being translucent corneous gray with a dorsal transverse band on each joint, and the portions of the mesothorax and metathorax darker or purple gray, and with the members somewhat lighter.

Habitat.— This is an imported European species, which is common throughout the greater part of those sections of the United States where apples are grown to any great extent. It is, however, much more common in the cooler parts of the country, being replaced to a certain extent by *Chionaspis furfurus* in the warmer sections.

There is but a single generation of this insect each year in the North, where the eggs hatch in the latter part of May, or early in June, and two generations in the South.

This species is said to infest many different plants; but in nearly if not every case the opinion respecting the specific identity of the forms occurring on other plants with that upon apple has been based upon the characters presented by the scale. These characters being insufficient to distinguish this species from closely allied forms, it is very desirable to confirm these observations. I have, however, found about twenty different species of plants infested by one or more species of Mytilaspis, which, after the most careful study of structural characters, I am unable to distinguish from *M. pomorum.* The greater part of these plants are trees growing in the parks and along the streets of Washington; and if the scale with which they are infested is *M. pomorum,* it is a very remarkable fact that, notwithstanding the abundance of it on these trees, apple trees growing in the immediate vicinity are not infested, and, too, although the male of *M. pomorum* is rare on apple, it is not at all so on the other plants. The following is a list of the plants upon which I have found this form of Mytilaspis: linden, hop tree, bladder nut, horse-chestnut, maple, an exotic amorpha, water locust, raspberry, hawthorn, currant, *Ribes alpinum, Lonicera pulverulenta,* ash, elm, hackberry, *Planera kakii,* willow, poplar, and yucca.

Genus **PARLATORIA** Targioni-Tozzetti

The following are the characters of this genus as given by Signoret: "Species of which the scale of the female is long, narrow at the base, then enlarging suddenly; the exuviae of a rounded oval form." "Four groups of pores only."

"The margin of the anal segment is indented and presents in each notch some plate-like scales." "On the upper side near the margin two rows of isolated pores." "The scale of the male of the same color as that of the female and much smaller."

Only two species of this genus have been described: *P. proteus* Curtis and *P. zizyphi* Lucas; I add a description of a third. A comparative study of *P. zizyphi, P. pergandii,* and two undescribed species in the collection of the department shows that there is very little variation in the *number* of the appendages of the last segment of the female; specific characters are to be found in the *shape* of these organs, and the *position* of the spines. I have not seen *P. proteus.*

* Fifth Missouri Report. p. 95.

PARLATORIA PERGANDII, new species

PERGANDE'S SCALE

(Plate XI, fig. 4; Plate XX, fig. 5; Plate XXI, fig. 8)

Scale of female.— The scale of the female varies in form; sometimes it is nearly circular in outline, with the exuviae upon one side; usually, however, it is somewhat elongated, with the exuviae at one end; color of scale, dirty gray; the first skin is naked; the second is covered with a very thin film of secretion, and occupies about one-third of the length of the scale; length of scale, 1.6 mm. (.06 inch).

Female.— The female is nearly as broad as long, and varies greatly in color; some specimens are almost entirely white, with only the end of the body slightly yellow; others are entirely yellow, and some are purplish, with the posterior end of the body yellow; eyes black. The last segment presents the following characters:

There are only four groups of *spinnerets,* each usually consisting of eight or nine; but the number in each group varies from four to ten.

There are three pairs of well-developed *lobes;* each lobe is widest near the middle, tapering anteriorly, and suddenly narrowed posteriorly. There is a fourth rudimentary lobe upon each side about midway between the third lobe and the penultimate segment; this lobe is irregularly rounded and produced into a papilla at its distal extremity; there is a similar lobe on the penultimate segment, cephalad of the posterior plate of that segment. Connecting the bases of the lobes are crescent-shaped thickenings of the body wall, which are in reality the thickened margins of elongated pores placed at right angles to the median line of the body. There is one of these pores in each of the following places: between median lobes; between median and second lobes; between second and third lobes; and there are two between third and fourth lobes; also two between fourth lobes and the penultimate segment.

There are two *plates* between the median lobes; two between first and second lobes; and three between second and third lobes. These are similar in shape, and in each case extend caudad as far as the tips of the lobes. Each plate is oblong, with the sides parallel and with the distal extremity fringed. Between the third and fourth lobes are three plates varying in shape from the form just described to palmate; the middle member of this group is usually as large as the other two combined. The three plates cephalad of the fourth lobe are usually palmate.* The three segments preceding the last usually have five or six plates each, on each lateral margin; these plates are rounded and produced into a single papilla at the distal extremity. The fourth segment preceding the last often bears one or two plates also.

Each lobe bears a *spine* on its dorsal surface; that of the fourth lobe is situated near the center of the lobe; each of the others is near the lateral margin of the base of its lobe. The spines on the ventral surface (except the first, which is obsolete) are longer and more conspicuous; the second, third, and fourth are each situated dorsad of the lateral margin of the first plate, laterad of the second, third, and fourth lobes, respectively. Each of the three segments preceding the last bears a conspicuous spine near the middle of each lateral margin.

* In the most closely allied of the described species—*Parlatoria proteus* Curtis—the plates of the last segment according to the figures and description of Signoret have a different form, being smooth on the mesal margin and serrate on the lateral.

Egg.— The eggs and young larvae are purplish. Twenty-seven eggs were observed under one scale; but in another instance the abdomen of a female was more than half filled by five eggs.

Scale of male.— The scale of the male is long and narrow; the larval skin is at the anterior end, and occupies a little more than one-third of the length of the scale; the lateral margins of the scale are prominent; the central part is not carinated and is very seldom higher than the sides; usually, and especially with old scales, after the adult has emerged the central part is depressed, giving that part of the scale posterior to the larval skin the form of a gutter.

The larval skin is grayish yellow, with the central part a very dark green; the excretion is light gray; length of scale, 1 mm. (.04 inch).

Male.— The male is purplish in color, with the disk of the thorax nearly colorless, with the exception of some irregular purplish spots, and the sutures, which are brownish; the eyes are large and very dark. (Plate XXI, fig. 8.)

Habitat.— This species infests the trunk, leaves, and fruit of the citrus trees in Florida. It occurs more abundantly on the bark of the small limbs than on any other part of the tree; occasionally, however, it very thickly infests the fruit. Frequently it may be found on Florida oranges in the northern markets, but I have never observed it on imported fruit. And as I have not yet found it infesting native plants I can offer no suggestions as to whence it came. The scales so closely resemble the bark in color that a tree may become very badly infested before attracting attention.

Number of generations per year.— The length of time occupied by a generation of this species varies greatly, according to the season of the year. Thus we observed that in a brood which hatched March 31 the larvae began to molt on the twenty-second day; the first male pupa was observed on the forty-second day; the second molt of the females began on the forty-fifth day; the first adult males were observed on the forty-ninth day; and the females did not begin to oviposit until they were more than two months old. In another brood which hatched April 26 there were developed females which began to oviposit on the forty-fifth day. And the females of still another brood which hatched June 23 began to oviposit when only forty-one days old. These observations were made in the breeding-room of this department in Washington. In the open air in Florida the periods are probably even shorter.

It gives me great pleasure to dedicate this important species to Mr. Th. Pergande, whose patient labors, although but little known to the public, have done much to advance economic entomology.

Genus **FIORINIA** Targioni-Tozzetti

This genus includes species of Diaspinae in which upon the scale of the female only one larval skin is visible at the anterior extremity; the second skin is present, but it is entirely covered by secretion. This skin is large, covering the insect entirely. The scale is narrow at its anterior end; it soon widens, and the sides are parallel throughout the greater part of its length. The three anterior groups of spinnerets are united, forming a continuous line.

The scale of the male is similar to that of the female, but smaller.

Only one species of this genus has been described heretofore — the *Fiorinia pellucida* of Targioni-Tozzetti — which is said to be common on many plants in hothouses, and especially upon *Areca aurea* and *Phytelephas macrocarpa.* As yet this species has not been reported from

this country. We have, however, a very pernicious pest which belongs to this genus, and of which I offer the following description:

FIORINIA CAMELLIAE, new species

(Plate XI, fig. 7; Plate XIX, fig. 4; Plate XX, fig. 4)

Scale of the female.— The scale of the female is yellowish brown, with the larval skin yellow, and a thin margin to the remainder of the scale white. That part of the scale which covers the second skin has a prominent, longitudinal, central ridge, which is dark brown; the sides of the scale sloping from this ridge are more or less wrinkled.

Female.— The fully grown female is of a pale yellowish brown color, with large irregular lemon-yellow spots. The last segment presents the following characters (Plate XIX, fig. 4, and Plate XX, fig. 4):

The anterior group of *spinnerets* consists of about nine, arranged in a single row; the anterior laterials of about nine each, usually in a double row, and continuous with the anterior group; and the posterior laterals of about sixteen, arranged more or less regularly in a double row.

There are only two pairs of *lobes* present, and their margins are conspicuously serrate. The caudal extremity of the segment is deeply notched, and the first pair of lobes is borne by the margins of this notch. The second lobe of each side is deeply incised; the median lobule is the larger.

The *plates* are simple, slender, tapering, and extend caudad of the lobes; there is one laterad of each lobe, and sometimes one on the lateral margin of the segment.

There is an elongated *pore* laterad of each of the first and second plates; one nearly midway from the end of the body to the penultimate segment, and one near that segment.

There is a pair of *spines* between the median lobes, which appear to be neither ventral nor dorsal. The spines on the dorsal surface are as follows*: one delicate one laterad of anterior portion of first lobe; a larger one posterior to it at the base of the first plate; a large one on the lateral lobule of second lobe; a similar one about midway between the second and third pores, and also one between the third and fourth pores. On the ventral surface there are only three spines on each side; one at the base of the second plate, and one laterad of each of the two lateral spines of the dorsal surface.

Egg.— The eggs and young larvae are lemon-yellow.

Habitat.— This is a very troublesome pest of the camellia in the conservatories of this department. It also infests a palm (*Kentia balmoriana*) and *Cycas revoluta.*

Genus **ASTERODIASPIS** Signoret

The females of this genus resemble those of Asterolecanium Targ.-Tozz. Around the lateral edge and upon the dorsum are spinnerets, which secrete a fringe which persists upon the sides but which upon the back melts down and forms a continuous whole, which constitutes in the old individuals a hard and consistent shield, slightly iridescent, which covers the whole insect. When the females have deposited their eggs, the body shrinks up into the cephalic end of the covering so that

* Note that the figure of the margin of this segment (Plate XIX, fig. 4) represents the *dorsal* surface. In all other cases in this report the figures of the last segment represent the *ventral* surface.

there appears to be only a sac inclosing the eggs, which one would naturally take to be the body of the female. The male scale is of a long oval, with a weak median carina, and showing under the microscope an elegant fringe around the edge similar to that of the female scale.

ASTERODIASPIS QUERCICOLA (Bouché)

(Plate XI, fig. 9)

Adult female.— Of a dark brown or a clear yellow color, nearly round in outline, furnished at the anal extremity with a rounded lobule and above with transverse striae, which represent the abdominal segmentation. Diameter from 1 to 2 mm.

The skin is covered with quite a large number of tubular *spinnerets.* The circumference of the body is ciliated with a fine radiating fringe secreted by openings upon the edge of the body. This fringe is double, formed of a row of large tubes joined together two by two, secreted by double openings, and another row, smaller, secreted by smaller openings placed below the others.

These insects are very closely applied to the bark, forming for themselves, in fact, slight depressions, so that it is very difficult to lift them. Occasionally, however, one of the yellow scales (in which the body of the insect has shrunken up to the end) is slightly elevated at one side, perhaps to allow for the exit of the young. On lifting one of the scales there remain upon the bark floury marks corresponding to the stigmata.

Male.— The male scale is of a long oval, 1 mm. in length by 0.6 mm. in width; of a clear brilliant yellow with a weak median carina, and with a fringe similar to that of the female.

The male is brownish yellow upon the head and thorax, and of a clearer yellow upon the abdomen, the base of which is a little darker; the antennae and legs almost black, the prothorax and mesothorax darker than the rest, the transverse band of the metathorax perfectly black as well as the eyes. The wings are large and of a transparent whitish gray. The abdomen is large and rounded; the stylet is dark yellow and .35 mm. long.

Habitat.— Upon the imported oaks on the Department of Agriculture grounds at Washington. Only the females were found and the male description is taken from Signoret. The species is not a common one in Europe, but is occasionally quite destructive to an individual tree.

Subfamily LECANINAE

Genus **CEROPLASTES**

The species belonging to this genus are furnished with a thick covering of waxy material, which does not, however, adhere closely to the insect. This covering is formed of layers secreted by the spinnerets. Some of the species have tuberosities upon the back which are larger or smaller according to the age of the insect, and which entirely disappear at full growth, when, from being more or less flat with tuberosities or nuclei with concentric lines, they become smooth and globular. The antennae are 6-jointed, the third being the longest. (In the larva state the fourth and fifth appear as one.) The legs are long. The claw is furnished with four digitules, of which the two shortest are very large and horn-shaped.

The male of this genus is not known.

CEROPLASTES FLORIDENSIS, new species

THE FLORIDA CEROPLASTES

(Plate IV, fig. 2)

Adult female.— Subglobular in form, the point of attachment to the twig or leaf being concave. Length from 2.5 to 3 mm. Color, when naked, reddish brown; covered with an apparently homogeneous layer of waxy excretion, which is usually brownish on the dorsum and dirty white towards the edges; some specimens are irregularly mottled brownish and yellow-white. Antennae 6-jointed, joint 3 nearly as long as all the others together. Legs normal in all respects. The margin of the body in the region of the stigmata is furnished with groups of minute arrow-shaped tubercles, constricted at the base, and between these groups bristle-shaped spinnerets. (We doubt whether these arrow-shaped tubercles will prove of specific value, but they are only mentioned by Signoret in two species, *C. Vinsonii* and *C. Fairmairii,* in the former case accompanied by the bristles, in the latter without them.)

Egg.— Ellipsoidal in form; 0.25 mm. long and about half as wide. Color, light reddish brown.

Newly hatched larva.— Moderately slender; antennae 6-jointed, joint 6 furnished with a number of very long hairs. Tarsi as long as tibiae; the two digitules of the claw are slender and but slightly expanded at the tip; of the other two tarsal digitules, the distal one is very short and slender and with but a very slight expansion, while the proximal is long and stout and has the normal appearance. The two bristles of the pre-caudal lobes are very long, while those of the caudal lobes are very short. The color is light reddish brown, with slightly paler legs and antennae.

Growth of insect.— The young lice are very active, and upon hatching spread at once in all directions, settling usually in from one-half to three-quarters of an hour, and usually upon the upper surface of the leaf near the midrib. While engaged in inserting the proboscis into the leaf the legs and antennae are all in motion, but once fixed they are all drawn under the body, and the insect appears motionless and memberless. At two days after hatching, two parallel dorsal ridges of white secretion, meeting in front and behind and dentate along the inner edges, made their appearance.* At three days these ridges were plainer, divided transversely at the middle, and some of the inner dentations had grown so as to touch those of the opposite side. Around the subdorsal portion were bits of white secretion, apparently eight on each side, one behind each eye, and a larger one between the eyes. At five days the subdorsal spots had increased in size, especially the one between the eyes, and the first, second, and fourth thoracic pairs and the seventh and eighth abdominal pairs. (There are now seen to be four thoracic and eight abdominal pairs of these spots in addition to the large one between the eyes.) The dorsal secretion at this time forms almost two compact masses, leaving only a very narrow line through which the body is still to be seen. At six days the dorsal secretion had become entirely united, and the tufts, as we may now call them, increased in length, the first abdominal pair being shortest and the others towards

* The periods given here are as noticed in a cool breeding-room at Washington; in Florida they are probably shorter.

the anal end gradually increasing in size. At nineteen days the dorsal secretion had formed a compact oval mass, and there were fifteen distinct lateral tufts to be seen, seven on each side and one at the point. At this stage all the specimens which we have attempted to rear have died. Many lived for months without perceptible change, and the conditions are probably not favorable for the production of further secretion or for the change of the white tufts into the waxy plates which are seen in the next stage of growth.

When the insect has attained a length of from 1.5 to 2 mm., it is found to be covered with nine irregular waxy plates, the central one very small and the six lateral ones larger, of an irregular oval in shape, while the cephalic and caudal ones are triangular, the apex of the triangle towards the central plate. Near the center of each of these plates is usually a small bit of the white secretion (usually larger with the central plate than any other). The plates are even at this time not well differentiated, and, with the increase of the insect in size, the dividing lines become lost, the lateral plates extend over the central, until at full growth the wax presents the appearance of a continuous, even covering. At any time previous to full growth, after the plates have been formed, if the waxy shield be removed, six very large prominences will be observed, three on each side of the insect, corresponding to the six original lateral plates. As the body fills with eggs and expands, these tuberosities grow less perceptible, until in the old female they are not to be seen at all.

The half-grown specimens are usually dirty yellowish white in color, often tinted with pinkish or reddish brown.

Food plants.— While the principal economic importance of this species is derived from the fact that it is to be found upon all the different citrus plants in different parts of Florida, yet it is also found upon fig, pomegranate, guava, tea (?), quince, and Japan plum (*Biotrites Japonica*). I have also found it upon red bay, oleander, sweet bay, very abundantly upon the gall berry (*Ilex glabra*), upon the common myrtle, and upon an ericaceous plant belonging to the genus Andromeda.

Synonymical.— This species is treated under the name of *Ceroplastes rusci* Linn. by Mr. Ashmead in his *Orange Insects*, and what is probably the same insect was similarly identified by Professor Riley in the Department of Agriculture report for 1878, p. 208. Compared with *C. rusci*, however, *C. Floridensis* presents several marked differences, the most easily noticeable being the small size of the central plate and its entire disappearance so early in the life of the insect. With *C. rusci*, according to the figures of Targioni and Signoret, the central plate is much larger than any of the others, and continues so as long as any dividing lines can be observed.

From the specific name which I have given this insect it will be seen that I consider it indigenous. I found it common in all parts of Florida which I visited, even upon the pine barrens, many miles from any orange grove. Moreover, I have always found it more abundant upon the gall berry than upon the orange or any cultivated plant. Mr. Ashmead considers it as imported, but his specific identification has undoubtedly misled him.

The orange growers cannot expect to free their groves from this insect so long as the gall berry grows about them as abundantly as it does in some places. I have always found those bushes growing in wet places more extensively infested than others.

CEROPLASTES CIRRIPEDIFORMIS, new species

THE BARNACLE SCALE

(Plate IV, fig. 3)

Adult female.—Average length 5 mm., width 4 mm., height 4 mm. When naked the color is dark reddish brown; the shape sub-globular, with a strong spine-like projection at the anal end of the body. The waxy covering is dirty white, mottled with several shades of grayish or light brown, and even in the oldest specimens retains the division into plates, although the form is more rounded and the dividing lines by no means as distinct as at an earlier age. There are visible a large convex dorsal plate, and apparently six lateral, each with a central nucleus; the anal plate, however, is larger, and shows two nuclei, and is evidently two plates joined together. Antennae 6-jointed, and proportioned as with *C. Floridensis.* Legs long; tibiae nearly twice as long as tarsi; digitules of the claw very large. The other tarsal pair very long and slender, but with a very large button. The skin is seen in places to be furnished with many minute, round, transparent cellules, probably *spinnerets* (indicated and so called by Signoret in his description of *C. Vinsonii*), and along the border are small groups of the constricted arrow-shaped tubercles mentioned in the last species; but the bristle-shaped *spinnerets* seem to be wanting, as in *C. Fairmairii* Targ.

Egg.— Length 0.35 mm., rather slender, little more than a third as thick as long. Color light reddish brown, rather darker than the egg of *C. Floridensis.*

Young larva.— Very slender; dark brown in color; legs and antennae as with *C. Floridensis.*

Growth of insect.— The growth of the insect and the formation of the waxy covering seems to be very similar to that of the last species. Soon after the larva settles the same two dorsal ridges of white secretion make their appearance, but soon split up into transverse bands. Examined on the fifth day after hatching, a larva showed seven distinct transverse bands, the anterior one being in the shape of a horseshoe. At the same time the lateral margin of the body was observed to be fringed with stiff spines, seventeen to a side. At nine days the small horseshoe-like mass had extended so as to nearly cover the thorax, and the transverse bands had lengthened and widened until they presented the appearance of a nearly complete shield to the abdomen, serrate at the edges. Fifteen lateral tufts, such as were noticed in *C. Floridensis,* and such as Targioni figures in the larva of *C. rusci* (Stud. Sul. coccíniglie, plate 1, fig. 6) had appeared, though still small.

At this stage of growth, as with the last species, all development seemed to stop, although the specimens lived on for months, the temperature in the breeding-room probably not being favorable to the formation of the plates.

The smallest specimen in the collection with the plates already formed measures 2 mm. long by 2 mm. wide and 1 mm. high. The color is light brown, and the wax has a somewhat translucent appearance. The dorsal plate is seven-sided; it is truncate anteriorly and pointed posteriorly. From each angle radiates a suture to the lateral edge, thus forming seven lateral plates, of which a single one is above the head, while above the anus is the suture between two. Through this suture projects the anal

spur. Each plate has a dark brown patch in its center, and in the center of each brown patch is a bit of the white secretion.

Habitat and food plants.— Found at Jacksonville and in Volusia County, Florida, on orange, quince, and on a species of Eupatorium, often in company with *C. Floridensis,* although it was by no means so common a species.

Genus **PULVINARIA** Targioni

The genus Pulvinaria is not well defined. It was erected for those species of Lecaninae in which the females after fecundation secrete below and at the posterior end of the body a mass of cottony material which forms a nidus for the eggs.

But one species has been described in this country — the *Pulvinaria innumerabilis* of Rathvon, a very abundant species in many localities upon the maples. It is figured upon Plate XI, figure 6. Interesting papers upon the species will be found in the Proceedings of the Davenport Academy of Sciences, volume ii, and in the American Naturalist, volume xii, page 655.

Genus **LECANIUM**

This species includes those species of Lecaninae which are naked and at first boat-shaped, taking on, however, after impregnation very diverse forms, from nearly flat to globular.

Signoret has divided the genus into six sections.

Those species which we shall consider may be placed in three of these sections, which are separated as follows:

1. Flat; the lobes of the body visible; generally viviparous. L. HESPERIDUM.
4. More or less globular, the skin with dermal cellules; tarsi truly articulated and antennae 8-jointed................L. HEMISPHAERICUM.
5. Rugose, with dorsal carinae............................L. OLEAE.

LECANIUM HEMISPHAERICUM Targioni

(Plate VIII, fig. 3)

Adult female.— Shape approaching hemispherical with the edges flattened. Average length 3.5 mm., width 3 mm., height 2 mm. The shape and proportions vary somewhat according as the scale is formed upon a leaf or a twig. Upon the rounded twig it loses something of its hemispherical form, becomes more elongated, and its flattened edges are bent downwards, clasping the twig. In such cases, of course, its height becomes greater and its width less. The color varies from a very light brown when young to a dark brown, occasionally slightly tinged with reddish when old. The oval cells of the skin vary in length from .01 to .04 mm., and each cell contains a large granular nucleus. The antennae are 8-jointed with joints 1 and 2 short and thick; joint 3 is the longest, and the succeeding joints decrease gradually in length to joint 8, which is longer than the preceding. Occasionally a specimen is found in which joint 5 is longer than joint 4, and I have seen individuals in which this was the case with one of the antennae while the other was normal. The legs are long and rather slender; the bristle on the trochanter is long; the articulation of the tarsi is very well marked. (This fact has suggested to Signoret that the insects of this series are less fixed than their congeners.) The tarsal digitules are, as usual, two long and two short, those

of the claws spreading widely at summit, and very stout at the base. The anal-genital ring (more easily seen than in the other species we describe) is furnished with eight long hairs. The anal plates are triangular with rounded corners, and are furnished with two long hairs upon the disk, and three much shorter ones at the tip.

Egg.— The egg is ellipsoidal in form, and 0.15 mm. in length. In color it is whitish with a yellowish tinge, and is smooth and shining.

Newly hatched larva.— The antennae are only 7-jointed, and the tarso-tibial articulation is hardly marked.

This bark louse was first noticed in the orangery of the department, upon the leaves and twigs. It was also noticed upon various greenhouse plants, Disipyrus, Chryosphyllum, sago palm, and *Croton variegatum.* Shortly after being found here it was received from correspondents in California as infesting orange and oleander. During my visit to California I found it upon a single orange tree in the yard of Mr. Elwood Cooper, near Santa Barbara.

Actual observation shows the surmise of Signoret as to the locomotive powers of this insect to have been correct. We have seen the adult insects when removed from their positions crawl back with apparent ease.

LECANIUM HESPERIDUM Linn.

(Plate VIII, fig. 2)

Adult female.— Length 3 to 4 mm. Color yellow, inclined to brown upon disk, often quite dark; shape, elongate oval, nearly flat; smooth and shining, with sparse punctures upon the disk; after death the border above often becomes wrinkled radially for narrow space. The antennae are 7-jointed, the fourth and seventh subequal in length and the third but little shorter; 1, 2, 5, and 6, short and subequal. The legs are long and comparatively slender, with the tarsi shorter by one-fourth than the tibiae; the hair upon the trochanter is very long, and the tarsal claw is large; the tarsal digitules are long and much widened at their extremities; and also stout at the base. The anal ring is very small and is furnished with six long stout bristles.

Young larva.— Long oval; antennae with six joints only, of which the third is the longest.

The male of this species has never been found, although it has been studied from the time of Linnaeus down. The species is viviparous. This is the commonest and most widely spread of any of the bark lice we have considered. In the United States we have received it from all quarters. Our notebooks show, for example, New York, District of Columbia, Georgia, Florida, Utah, California. All through the North it is to be found on greenhouse plants, and in the latitude of Washington and south it is found the year round on ivies, oranges, and other plants. In Europe Signoret speaks of finding it principally upon oranges, both in greenhouses and in the open air, but also states that it is found upon all surrounding plants.

We have no data concerning number of generations each year; in fact they are not well marked.

Three species of parasites have been reared from this bark louse, and all have been described in Mr. Howard's paper on parasites. The first, *Cocophagus cognatus,* from *Lecanium hesperidum,* on orange in Florida; the second, *Comys bicolor,* from scales on ivy at Washington; and the third, *Encyrtus flavus,* from orange scales in California.

LECANIUM OLEAE Bernard

THE BLACK SCALE OF CALIFORNIA

(Plate VIII, fig. 1)

Adult female.— Dark brown, nearly black, in color; nearly hemispherical in form, often, however, quite a little longer than broad; average length from 4 to 5 mm.; average height, 3 mm. Dorsum with a median longitudinal carina and two transverse carinae, the latter dividing the body into three subequal portions; frequently the longitudinal ridge is more prominent between the transverse ridges than elsewhere, thus forming with them a raised surface of the form of a capital H. The body is slightly margined; outer part of the disk with many (18 to 30) small ridges which extend from the margin halfway up to center of dorsum. Viewed with the microscope, the skin is seen to be filled with oval or round cells each with a clear nucleus; the average size of the cells being from .05 to .06 mm. in length, while the nuclei average .02 mm. in diameter. The antennae are long and 8-jointed, the two basal joints short; joint 3 longest, joints 4 and 5 equal and shorter, joints 6 and 7 equal and still shorter, joint 8 with a notched margin and almost as long as joint 3. Legs rather long and stout, the tibiae being about one-fifth longer than the tarsi. The anal ring seems to bear six long hairs.

Egg.— Long oval in shape, .04 mm. in length, yellowish in color.

Newly hatched larva.— There is nothing very characteristic about the young larvae; they are flat, and their antennae are only 6-jointed.

The black scale is stated by Signoret to be properly in France an olive scale, sometimes, however, becoming so common as to occur on all neighboring plants also. In California we find it infesting the greatest variety of plants, and becoming a very serious enemy to orange and other citrus trees. I have found it at Los Angeles on orange and all other citrus plants, on olive, pear, apricot, plum, pomegranate, Oregon ash, bittersweet, apple, eucalyptus, Sabal palm, California coffee, rose, cape jessamine, *Habrothmus elegans*; and elsewhere upon an Australian plant known as *Brachaeton,* and also upon a heath. It preferably attacks the smaller twigs of these plants, and the young usually settle upon the leaves.

The development of this species is very slow, and it seems probable that there is only one brood in a year. Specimens observed by Mr. Alexander Craw at Los Angeles, which hatched in June or July, began to show the characteristic ridges only in November. Mr. Craw has seen the lice, even when quite well grown, move from twigs which had become dry and take up their quarters on fresh ones.

Although carefully looked for, the males, like those of so many other lecanides, have never been found.

A dark brown bark louse has been sent me from Florida, on live oak, holly, oleander, orange, and one or two unknown plants, by Dr. R. S. Turner, of Fort George, which appears to be identical with *Lecanium oleae.* It is, however, by no means as abundant or injurious in that State as in California.

Natural enemies.— Enormous quantities of the eggs of the black scales are destroyed by the chalcid parasite *Tomocera californica,* described on page —— of this report. Particulars as to the work of this parasite are given at the same place. Upon one occasion (August 25, 1880), I found within the body of a full-grown female a lepidopterous larva, which was very similar in appearance to the larvae of the species of *Dakruma*

described in my last report as destroying bark lice. The specimen, however, was lost, and no more have been found since.

A number of beetles of the genus Latridius were found under scales which had been punctured by the Tomocera, but probably would not destroy the live insect. Many mites were found feeding upon the eggs and young. The infested trees were also swarming with the different species of ladybugs (Coccinellidae).

Subfamily COCCINAE

Genus **KERMES** Targ.-Tozz.

(Plate IX, fig. 1)

The following characterization of this genus is taken from Signoret: Body perfectly globular or with a slight incision for insertion on the twig or branch. On an external examination no trace of antennae, legs, or even mouth parts is to be observed, and the insect presents precisely the appearance of a gall.

In the larvae, however, the true characters of the Coccinae are seen — multiarticulate lower lip and the absence of the anal plates. The larval characters are the ones which have been principally used in the description of species as they are easy to find. They (the larvae) are long, oval, the abdomen plainly segmented and deeply cleft at the extremity, except in *K. vermilio* and *K. ballotae.* Upon each segment there are several spines at the lateral edge and several hairs upon each disk. The lateral lobes have each a bundle of spines and a very long hair. Antennae 6-jointed, joint 3 longest. With all the legs the tibiae are shorter than the tarsi. With the adult the antennae and legs appear natural; but in very old individuals, which have secreted the horny covering, the antennae are still present but deformed; so also with the legs, but the latter are sometimes entirely wanting.

The males resemble those of other Coccinae, and are inclosed in a little white felt-like sac. Head globular, with four eyes and six ocelli in *K. bauhinii* (the only species observed by Signoret). The antennae are very long, joint 3 longest, joint 10 shortest, and carrying several hairs with buttoned tips. Wings long. Abdomen long, with a short genital armature and two long bristles each side. Legs long, the tibiae longer than the tarsi, the latter with a long claw and the four ordinary digitules.

There are in the collection of the department several species belonging to this genus, which we have collected in Florida, Alabama, Louisiana, California, New York, and District of Columbia. For want of time I am unable to characterize these now. The species represented on Plate IX, figure 1, occurs on *Quercus* —— in California. The only North American species which has been described is *Kermes galliformis* Riley, described in the American Naturalist, volume xv, page 482 (June, 1881).

Genus **ERIOCOCCUS** Targ.-Tozz.

The following characterization of this genus is taken from Signoret: Species early inclosed in felt-like sac, soon after fecundation and before oviposition. At the posterior extremity of the sac is a minute opening probably for the exit of the young. The young larvae approach those of Kermes in appearance. They are more or less oval, rounded anteriorly, attenuated posteriorly; the lobes on each side of the anal ring highly developed. Upon the back are several distinct rows of spiny tubular spinnerets; these rows are altered in the adult to a considerable mass of

spinnerets. The antennae are 6-jointed in the female, 7 in the male larva, and 10 in the adult male. At the base of the antennae there is in some species an elongated tubercle. The males resemble those of Dactylopius. Some of the antennal joints are furnished with buttoned hairs. The balancer has but a single bristle. The stylet is very short.

ERIOCOCCUS AZALEAE, new species

THE AZALEA BARK LOUSE

Adult female.— Length of sac, 3 mm.; width 1.5 mm., the female herself being somewhat smaller. The sac is dense, pure white, and covered with protruding filaments of white secretion, especially in the younger individuals; it is nearly oval in form, somewhat pointed at both ends. The female removed from the sac is dark purple, almost black; its shape is that of the sac, more rounded anteriorly and pointed posteriorly; its color is dark purplish, almost black; it is almost entirely naked, only a very small amount of the cottony secretion occurring on the ventral surface near anus. The whole dorsal surface is covered with long stout acuminate yellow spines, and also between these spines with minute pointed tubercles; there are also numerous pores; the underside of the body is comparatively smooth, bearing a very few of the shorter spines. The antennae are 6-jointed, but the bulb when the specimen is pressed under the cover glass often takes on the appearance of an additional joint; joints 1, 2, and 3 are subequal in length, joint 1 being perhaps a trifle the shortest; joints 4 and 5 are less than half as long as 1, and are subequal; joint 6 is nearly as long as 3; joints 3, 4, and 5 have each one or more bristles; joint 6 several, none, however, appearing buttoned at tip. The tibiae are two-thirds as long as the tarsi; tarsal digitules very long and slender, the claw large and strong. The lower lip is indistinctly 3-jointed, the basal joint widening slightly, and the final joint triangular; there are four or five hairs upon the disk and two at the summit. The anal lobes are small, each surmounted at tip by a very long bristle, and each bearing dorsally three of the long tubular spines, two at base and the other on the mesal edge, little more than half way to tip; there is also a bristle on the ventral surface. Anal ring with eight hairs.

Egg.— Length 0.27 mm.; color reddish purple. We have counted 50 eggs in one sac, and 52 eggs and 12 larvae in another.

Young larva.— Color bright carmine, legs and antennae yellowish red. The large tubular spines of the adult are present, but in much smaller number, and are yellow in color. The antennae are plainly 6-jointed, with joint 6 longest.

The half-grown individuals are covered with a shaggy coat of filaments precisely similar to that covering the sac.

The sac containing the male is similar in all respects to that of the female, except that it is less than half the size and rather narrower in proportion to its length. No males have been bred.

Habitat.— On the twigs and stems of azalea in the department conservatories at Washington; quite abundant.

Natural enemies.— The majority of the specimens of *E. azaleae* collected were parasited by the chalcid *Coccophagus immaculatus* Howard, described farther on.

Genus **RHIZOCOCCUS** Signoret

This genus was erected by Signoret* to receive an insect (*R. gnidii*) which he found on the roots of *Daphne gnidium,* and which differs, according to his description, from the species of Eriococcus in no important anatomical character, except in the antennae of the female being 7-jointed. The specimens (female only) which Signoret studied were naked; but he had not sufficient material to ascertain if the insect makes a sac or not in its most advanced stage.

During the past year I have studied two bark lice which agree with the characters given for Eriococcus, except that the females have 7-jointed antennae, and remain naked until they are fully grown. These species I place provisionally in the genus Rhizococcus, and submit the following characters, drawn from the species described here, for that genus.†

Genus RHIZOCOCCUS

Antennae of larvae and of the adult female 7-jointed; ano-genital ring with eight hairs; tarsi of both male and female each with four digitales; margin of body of young and of female in all stages fringed with tubular spinnerets, which are covered with a waxy excretion; adult male with single ocellus behind each eye, and a pair of bristles on each side of penultimate abdominal segment, each pair supporting a long white filament excreted by numerous pores at its base. The fully developed female makes a dense sac of waxy matter within which the eggs are laid and the shriveled body of the insect remains; the full-grown male larva makes a similar sac within which it undergoes its metamorphoses.

RHIZOCOCCUS ARAUCARIAE (Maskell)

THE NORFOLK ISLAND PINE COCCUS

(Plate X, fig. 1)

Eriococcus araucariae Maskell. Transactions and Proceedings of the New Zealand Institute, vol. xi, p. 218.

During the summer of 1880, I found very common on the Norfolk Island pine (*Araucaria excelsior*) growing in open air in southern California, a bark louse, which is probably the species that was described in New Zealand by Mr. Maskell the year previous under the above name.

When a tree is badly infested with this pest it becomes blackened with a black fungus, which I presume is *Fumago salicina,* which accompanies coccids on orange and other trees. This is often the first indication of the presence of the insect which is observed. But when an infested tree

* Annales de la Soc. Ent. de France, 1875, p. 36.

† M. Signoret, to whom I referred specimens of *R. araucariae,* is of the opinion that this species is not congeneric with his *R. gnidii,* and he advised me to establish a new genus for the species on araucaria. The mode of life of the two species is certainly very different, *R. gnidii* living on the roots of a plant, and *R. araucariae* upon the leaves; and it seems probable that the former never makes a sac. But until more is known of *R. gnidii* or of some undoubtedly congenic form, and structural differences between it and *R. araucariae* are discovered, I am unwilling to assume the risk of proposing an unnecessary generic name. In fact the great similarity between the species described here and those belonging to Eriococcus leads me to believe that it would be better to enlarge the characters of that genus so as to include species in which the antennae of the female are 7-jointed, and which are naked in their adolescent stages. The fact that it is sometimes difficult to decide whether an antenna is 6-jointed or 7-jointed (see description of *E. azaleae*) confirms this belief.

is carefully examined, numerous white cocoon-like sacs containing the full-grown insects may be seen closely applied to the sides or bases of the leaves. Frequently these sacs are so massed at the ends of the twigs that the bases of the leaves are completely covered. The immature insects are not so easily seen with the unaided eye, as they differ but little in color from the tree. They are greenish yellow, and are usually to be found in the angles formed by the bases of the leaves. The larvae of both sexes and the adult females are similar in form (Plate X, fig. 1*d*). The posterior end of the body is furnished with two prominent lobes, each terminated by a long hair. Between these lobes there is a conical mass of white waxy matter projecting backwards. The margin of the body is fringed with a row of tubular spinnerets. These spinnerets are more numerous on the adult female than on the larva; in both stages each one is covered with waxy matter, which often extends beyond the end of the spinneret. Excepting these filaments and the caudal tuft, but little excretory matter is to be seen; so that although the insect resembles a mealy bug in the form of its body it differs greatly in appearance. The female when full-grown measures 2.3 mm. (.09 inch) in length. When the female is ready to lay her eggs she excretes a cocoon-like covering to the body, composed of white waxen threads (Fig. 1). This sac is dense like felt, but easily torn; it is open on the middle line of the ventral surface or very much more delicate on that part. It adheres to the tree quite firmly, remaining where excreted after the death of the insect. As the eggs are laid, the body of the female shrinks away, making room for them, and finally it becomes a very small pellet in the anterior end of the sac, the remainder of the space being filled with eggs. These are light yellow in color. When the male larva is ready to undergo his metamorphoses, he secretes a covering to his body resembling the sac excreted by the female, except that it is very much smaller, measuring only 1.33 mm. (.05 inch) in length (Fig. 1). From this sac the adult insect emerges as a delicate fly-like creature, with two large wings and a pair of long waxen filaments projecting from posterior part of the abdomen; these filaments are very conspicuous, being white and longer than the body of the insect. (Plate X, fig. 1*a*.)

Color of body white with many irregular brown markings.

I have not sufficient data to ascertain the number of generations of this insect each year. August 27, I found specimens in all stages of development.

RHIZOCOCCUS QUERCUS, new species

(Plate X, fig. 2)

Female.— The tubular spinnerets are more numerous than in *R. araucariae,* and are not confined to the margin of the body but are distributed irregularly over the dorsum. They vary much in size and are curved and acuminate (Fig. 2*a*). Tarsi less than one-half as long as tibiae. Hair on trochanter nearly as long as femur.

Male.— I have only one specimen, which is much shriveled; this resembles *R. araucariae* except that the ocelli are placed farther caudad of the eyes than in that species.

Described from 17 females, 1 male, and very many larvae, all mounted in balsam.

Habitat.— On scrub oak at Rock Ledge, Fla.; upon gall berry, oak, and grass at Fort George, Fla. (Dr. R. S. Turner). The sacs (Fig. 2) of this species, of which I have very many specimens, very closely resemble those of *R. araucariae.* The sacs of the female are all large, indicating that the species is naked till full-grown.

Genus DACTYLOPIUS

To the genus Dactylopius belong the insects commonly known as mealy bugs. The antennae of the female are 6-jointed in the larva, and 8-jointed in the adult; the male larva has 7-jointed antennae. The tarsi are furnished with four digitules and the anal ring with six hairs.

DACTYLOPIUS ADONIDUM (Linn.) Signoret

THE COMMON MEALY BUG

(Plate XI, fig. 1)

Coccus adonidum Linn. Syst. Nat. (1767), 740, 4.
Dactylopius adonidum Signoret. Ann. de la Soc. Ent. de France, 1875, p. 306.

Under the specific name of *adonidum* have been classed the various species of "mealy bugs," common in greenhouses throughout the civilized world. It would be difficult, if not impossible, to determine beyond a doubt the particular form to which Linneus gave this name, more than one hundred years ago. Consequently the best course to follow is to accept the conclusions of Signoret, who has given this genus the most careful study that it has yet received. The following is the description of the species to which he applies the name given by Linneus:

The *female* is 2½ to 3 mm. (.1 to .12 inch) in length, and 1.5 mm. (.06 inch) in width; white, a little yellowish, with a brown band upon the middle of the back, the legs and the antennae a little brownish, powdered with a great quantity of floury matter secreted through pores scattered over the body; in addition to this, each lateral lobe or segment presents a secretion which forms a border of woolly appendages around the body varying in length; those near the posterior end of the body are longer, and four at the abdominal extremity are very long; the two internal ones are longest, equaling and sometimes surpassing the length of the body. The antennae are composed of eight points, of which the eighth is the longest, and the third and the second, fourth, and fifth the shortest and of equal length; sixth and seventh a little longer than the fourth and fifth. The antennae are slightly pubescent, especially at the summit of each joint. The legs are quite long, slightly pubescent, the tibia twice as long as the tarsus; claw strong and long, with the digitules slender and furnished with a very little knob. The abdomen presents upon the suture of the first and of the second segment and upon the median line a cicatrice more or less visible and more or less rounded; upon the suture of the fourth and fifth, on each side, nearer the margin than the median line, an oblong cicatrice; upon each segment, a great quantity of pores in the form of rounded points and some scattered hairs. Each lateral lobe presents a space with rounded pores, then two conical spines more or less strong; this is the apparatus secreting the cottony matter of which is formed each lateral appendage: the lobes of the extremity of the body have many more pores, and the conical spines are much larger; a little lower down arise two hairs, one of which is large; around these is condensed the secretion furnished by the pores. The anal ring is very large, dotted, and has six quite long hairs.

The *larva,* varying in size according to its age, is more flat, of the same elongated form, and of the same color, but differs in the antennae, which have only six joints. Other individuals, of a uniform shape and more elongated, have 7-jointed antennae; these are the males which are to undergo another molt, which very often is indicated by the rolling up of the oval setae and sometimes by the future antennae and legs,

which are already indicated within the members of the larva. In this type the tibia is hardly one-third longer than the tarsus.

The *male* we bred from larvae with 7-jointed antennae; in order to undergo their metamorphoses, they form little cottony sacs. The adult is long, of a brown, neither yellow nor red, with the segmentations paler. As it becomes older it grows darker, especially upon the head and the corneous pieces of the thorax. The wings are long, largely rounded, of a gray more or less deep, reddish towards the side. The poisers are long, yellow, with a single bristle hooked at the extremity. The prothorax is long, rounded upon the sides, straight in front, rounded behind, with a black arc upon the mesothorax. The abdomen is long, terminated by a rounded armature, thick, presenting some hairs. The lateral lobes of the last segment present two long threads of white cottony matter, secreted by numerous rounded pores; in the middle of each lobe are two long hairs and one smaller, around which the matter is condensed; the lobes above present much smaller ones, with two or three rounded pores. The head is thick, in the form of a ball a little truncated in front, more convex below than above, and pubescent, except upon the pigmentary circle of the eyes and ocelli. We have not determined exactly the number of the ocelli, which we think is four. The legs are long, with a large tarsus, flat, pubescent, presenting a very long and narrow claw. We have not been able to see the digitules of the claws. As to those of the tarsi, they are not larger than ordinary hairs with a very little knob at the extremity.

We have reproduced the figures of this species given by Dr. Signoret (Plate XI, fig. 1): 1, lateral lobe of the extremity of the abdomen of the female; 1*a*, antenna of the female; 1*b*, antenna of the male; 1*c*, leg with the four digitules of the female; 1*d*, anal ring with six hairs.

DACTYLOPIUS DESTRUCTOR, new species

THE DESTRUCTIVE MEALY BUG

(Plate XI, fig. 3; Plate XXII, fig. 2)

Adult female.— Length 3.5 to 4 mm.; width 2 mm. Color dull brownish yellow, somewhat darker than with *D. longifilis*; legs and antennae concolorous with body. The lateral appendages (seventeen on each side) are short and inconspicuous and are subequal in length. Upon the surface of the body the powdery secretion is very slight. In spite of the small size of the filaments, the spinnerets and the supporting hairs are as numerous and as prominent, or nearly so, as in *D. longifilis*; those upon the anal lobes being especially long. Antennae 8-jointed; joint 8 is the longest and is twice as long as the next in length, joint 3. After 3, joints 2 and 7, subequal, then 5 and 6, joint 4 being the shortest. The tarsi are a little more than half the length of the tibiae and the digitules are as in the preceding species; claws strong.

Egg.— Length 0.25 mm.; shape rather long, ellipsoidal; color light straw yellow.

Young larva.— Rather brighter-colored than the egg. Antennae 6-jointed with the female, with the same relative proportions as in the preceding species. Tarsi considerably longer than the tibiae. The lower lip is large, conical, and reaches almost to the posterior coxae.

Male.— Length 0.87 mm.; expanse of wings, 2.5 mm. Color light olive-brown, lighter than in following species; legs concolorous with body; antennae reddish; eyes dark red; bands darker brown than the gen-

eral color; anterior edge of mesoscutum and posterior edge of scutellum darker brown. Body, as will be seen from measurements, rather small and delicate compared with the size of the wings; head small, with almost no hair; antennae 10-jointed, joints 3 and 10 longest and equal; joints 2, 6, 7, 8, and 9 nearly equal and considerably shorter than 3 and 10; joints 3 and 4 subequal and a trifle shorter than the following joints. The lateral ocelli are each just laterad of the center of the eye, and not at its posterior border, as in the following species. (This, however, is a character which will not hold with specimens long mounted.) Prothorax short; legs sparsely covered with hairs; tarsal digitules extremely delicate, and the button is very difficult to distinguish; we have been unable to discover a trace of the pair belonging to the claw. The anal filaments and the supporting hairs are similar to those of the following species.

This species is readily distinguished from *D. longifilis* by the shortness of the lateral and anal filaments in the female. Indeed, for convenience's sake, we have been in the habit of distinguishing them as the mealy bug with short threads and the one with long. The life history of this species differs quite decidedly from that of *D. longifilis,* in that true eggs, which occupy quite a long time in hatching, are deposited. The female begins laying her eggs in a cottony mass at the extremity of her abdomen, some time before attaining full growth, and the egg mass increases with her own increase, gradually forcing the posterior end of the body upwards until she frequently seems to be almost standing on her head. The young larvae soon after hatching spread in all directions and settle — preferably along the midrib on the under side of the leaves, or in the forks of the young twigs, where they form large colonies, closely packed together. As mentioned in the description, they are only slightly covered with the white powder, and many seem to be entirely bare, with the exception of the lateral threads.

Habitat.— This species is very abundant upon almost every variety of house plant in the department greenhouses, but especially so upon the Arabian and Liberian coffee plants. On these plants they were found, curiously enough, in small pits or glands on the under side of the leaf, along the midrib. Almost every pit, of which there is one at the origin of each main vein, contained one or more young mealy bugs, and the larger ones whole colonies. The name *destructor* is, however, proposed for this insect from the damage done by it to orange trees in Florida, especially at Jacksonville and Micanopy, where it is the most serious insect pest of the orange.

Natural enemies.— The chalcid parasite *Encyrtus inquisitor* Howard, described in this report, was bred from a specimen of this mealy bug collected at Jacksonville, Fla. A small red bug was observed by myself and several of our correspondents to prey upon the mealy bug. The larvae of another species have been found, but the mature form has not been obtained. These last have the faculty of changing color quickly from red to brown.

The very curious larvae of a ladybird beetle, known as *Scymnus bioculatus,* were found feeding upon the eggs of the mealy bug at Orange Lake. These larvae mimic the Dactylopii so closely that they might easily be taken for them. They are covered by a white secretion, and from each segment exudes a white substance which forms long filaments like those of the mealy bug. Removing the powder the larvae are seen to be yellow in color, with two roundish dusky spots on the dorsum of each thoracic segment. Each segment of the body is furnished laterally with one long bristle and a number of small ones.

DACTYLOPIUS LONGIFILIS, new species

THE MEALY BUG WITH LONG THREADS

(Plate XI, fig. 2; Plate XXII, fig. 1)

Adult female.— Length 4 to 5 mm.; width 2 mm. Color very light dull yellow, legs and antennae a trifle darker. Body rather sparsely covered with a whitish powder. The lateral appendages, numbering seventeen on each side, are long, the two posterior ones on each side very long — equaling if not surpassing in length the whole body. Antennae 8-jointed; joint 8 longest, then 3, and then 2, the difference being slight; joint 5 is next in size, and 4, 6, and 7 are nearly if not quite equal. The tarsi are only one-third as long as the tibiae. The four tarsal digitules are present and are knobbed; those of the claw are short and thick (although by no means so much so as in Lecanium), and the others very slender, and with a very delicate knob. Antennae, tarsi, and distal ends of tibiae quite hairy. Along the lateral edge of the body are many tubercular spinnerets, in which large tubes can be seen running to the tips. Below these spinnerets, on each lobe, is a pair of sharp conical spines, and several longer or shorter hairs. The conical spines upon the last two segments are much larger than those upon any other. The anal lobes bear each a long hair. The anal ring is prominent, and bears the customary six large tubular hairs.

Larva.— In color similar to the adult. Antennae 6-jointed, the sixth joint longest — as long as the three preceding joints together; the others short and subequal. In the male larva the antennae are 7-jointed. The tarsi somewhat longer than the tibiae.

Male.—Wing expanse, 2.6 mm.; length of body, 1.3 mm. Color light olive-brown; antennae and legs darker brown; band slightly darker than the general color; anterior border of mesoscutum and posterior edge of postscutellum dark brown; eyes dark red; wings slightly dusky, with a faint bluish tinge. Body long and stout; head large, and strongly pilose behind the eyes. Antennae 10-jointed; joint 3 longest, joint 6 next; joint 10 a trifle longer than 9, and about the same length as 7 and 8. Prothorax very long; legs very hairy; only two tarsal digitules are to be seen, those of the claw being rudimentary; they are short, very delicate, and with an extremely delicate button. Anal lobes each with long filaments, which when the wax is removed show two long supporting hairs and one short one. The visible ocelli are seen just behind the lateral angle of the eye, on each side.

This species is one of two which are very common in the department greenhouses, and seems to be more abundant upon the ferns and the plants of the euphorbiaceous genus Croton than upon any others. The female is very active when disturbed, and is not found with the cottony egg mass to be seen with many species of Dactylopius. The young is born enveloped in a thin pellicle or pseudovum, which splits a few moments after birth and allows it to escape. The female surrounds herself with the cottony material, and the young cluster around and under the mother for some time. The growth is evidently quite rapid, and individuals of all stages are to be found at almost any time. The male larva, some time before pupation, forms for itself a little cottony sac or cocoon, in which it undergoes its transformations.

Genus PSEUDOCOCCUS Westwood

This genus is very near Dactylopius, and nearly all the characters are identical. In the adult female, however, the antennae are 9-jointed, those of the female larvae being 6-jointed and of the male larvae 7-jointed. The tarsi are not provided with the customary long digitules except in *Pseudoccus hederae.*

PSEUDOCOCCUS ACERIS (Geoffrey)

This species, stated by Signoret to be one of the most common in France, would seem to be comparatively rare in the United States. It has been collected by Miss Emily Smith on maple (*Acer saccharinum*) at Peoria, Ill., and forms the subject of quite an extensive article by her in the North American Entomologist, volume 1, page 73 (April, 1880). She also notes its occurrence at Lancaster, Pa., where it has been collected by Dr. Rathvon. The following description of the species is compiled from Signoret and Miss Smith:

Adult female.— Color, bright yellow (Smith), reddish yellow (Signoret). Length from 4 to 5 mm. Shape rounded oval, as large behind as in front. The dorsal integument is smooth, with the divisions into segments obscure; it is filled with spinnerets in the form of pores, and is also furnished with many delicate hairs, especially numerous upon the median part of each segment and at the extremity of the abdomen. The antennae are long and delicate, 9-jointed, second and third longest, the others diminishing in size and length except joint 9, which is longer than the preceding joint and acuminate at tip. The under lip is long, acuminate at tip, which is furnished with many hairs. The tibiae are nearly three times as long as the tarsi. The tarsal claws are rather short and toothed on their inner side, sometimes truncate at tip; there are only two digitules, those of the claw, the others being only simple hairs. The anal genital ring is large, punctated, and supports six quite long hairs.

Egg.— The egg is light yellow in color when first deposited, later becoming yellow-brown. Dimensions given by Miss Smith, 5 to 6 mm. long and 3 to 4 mm. wide; probably 0.5 to 0.6 mm. by 0.3 to 0.4 mm.

Young larva.— Color reddish yellow; shape elongated oval, narrow behind. Antennae 6-jointed, joint 6 as long as the three preceding joints together. The lower lip is 2-jointed. The body is surrounded by a series of spines and upon the disk of each segment is a series of eight tubercular spinnerets, with which alternate short hairs; in front of the head between the eyes are several longer hairs. The anal ring with six hairs; the lateral lobes large, each with one very long hair and several shorter ones. The tarsi a third longer than the tibiae.

The male larva is red and has 7-jointed antennae.

Male.— Color red. Antennae 10-jointed: joint 1 short and stout; joint 2 twice as long as 1; joint 3 three times as long as 1; joints 4 to 10 similar in size and form, decreasing slightly in length. Legs hairy; tarsi one-half as long as tibiae. Anal filaments longer than all the rest of the insect.

Genus COCCUS

In general appearance the genus Coccus resembles the foregoing considerably, but may be distinguished by the following characters:

The antennae are 7-jointed with the adult female, 6-jointed with the female larva, and 5-jointed with the male larva. The legs are very

slender. The anal ring is destitute of hairs. The eyes are smooth and there are two ocelli, this last character separating the genus from the following divisions.

COCCUS CACTI

THE COCHENILLE INSECT

The following description is taken from Signoret:

Adult female.— Dark reddish brown in color. From 6 to 7 mm. long, 4 mm. wide, and from 2 to 3 mm. high. Covered with a large quantity of white cottony powder; when this substance is removed it is seen to be strongly segmented, prismatic in form, in consequence of a dorsal carina, especially visible in dried specimens, and truncate behind, which gives it the form of a lance head. The antennae are short, conical, 7-jointed, the four basal joints short, thicker than long, joint 5 as long as thick, joint 6 a little longer, with a whorl of short hairs, joint 7 as long as the two preceding together, with ten or eleven short hairs.

Larva.— In the newly hatched female larva the antenna is 6-jointed, slender, joint 2 very short, 3 longer, but it soon becomes deformed and thick, even in the larva state. There are other larvae in which the antennae only seem to show five joints, the second having blended with the third; there is also another type of larvae which show only five joints. These differences indicate different states, either of the newly hatched larvae or of the female or male larvae. For these last we take those in which the legs are very slender and the antennae of which, seen upon the cast skin, show a very short basal joint, a second five times as long, the third and fourth short, and the fifth longest of all and a little slenderer.

The legs also vary according to the age and sex. In the old individuals they become short, thick, and often with very indistinct joints; when not deformed they are generally thick, with the tarsi longer than the tibiae in the larva, and almost as long in the old female. In the male larvae the legs are slenderer, with the tarsal claws very long and accompanied by the four-buttoned digitules. The skin is smooth, with groups of spinnerets here and there and a few scattered hairs. The newly hatched larva is oval, larger before than behind; the antennae and legs are long; upon the lateral edge of each segment are two spines, a line of hairs each side of the median line, and a group of spinnerets near the lateral spines; between the double median line and the lateral spine is another simple line of short hairs.

Male.— The male is of a reddish yellow, darker upon the head and thorax, with brown legs and antennae, and light gray wings. The head is thick, rounded, acuminate between the antennae, with four smooth eyes and two ocelli. The antennae are 10-jointed, with the fourth, fifth, and tenth longest, all joints furnished with a short pubescence, the hairs of which appear truncate; at the tip of the fifth and last joints is a much longer pubescence formed of buttoned hairs; joints 1 and 2 almost smooth, showing but one or two hairs (this is a character seen in no other genus). The legs are very long, with a sparse pubescence formed of little hairs scattered over the disk and upon the sides; the tarsus is a third shorter than the tibiae and furnished with two very long digitules; the claw is very slender and very long, with its two digitules extending a little beyond it. The abdomen, paler in color, is furnished upon each side with a transverse line of small hairs; the lateral lobes of the extremity each with a protuberance covered with many spinnerets, and

at its end furnished with three hairs which support the waxy matter of the two caducous filaments, which are twice as long as the body of the insect. Between the two filaments is the copulating armature, composed of a very large tubercle, accompanied by a stylet shaped like a ventrally curved claw. Upon the middle of the abdomen is sometimes seen a small brown spot which forms a longitudinal band. Upon the prothorax anteriorly is a darker transverse band as well as upon the meso and metathorax, and sometimes three longitudinal bands from the neck to the metathorax. Ventrally, the framework of the sternum is browner. Although several individuals have been examined, we (Signoret) have never seen any balancer. The wings extend for a third of their length beyond the abdomen, and are widely rounded at the extremity; the nervures are brownish yellow with a reddish tint towards the body.

The cochenille insect of commerce, although an indigene of Mexico, has been imported into various other countries and is cultivated notably in the Canary Islands, in Algiers, and in Spain. Specimens from China seem, according to Signoret, to be but varieties of this species. Specimens of what is probably this species were collected by Dr. R. S. Turner at Fort George, Fla., upon a yellow flowering cactus; species unknown.

Genus **ICERYA** Signoret

Antennae 11-jointed; body covered by a cottony matter of several shades of color and with a secretion of still longer filaments. Skin with rounded spinnerets and with long scattered hairs. Antennae of nearly the same size throughout their whole length and with a long pubescence. The digitules of the claw elongated and buttoned; of the tarsus as simple hairs. Genital apparatus terminating in a tube internally with a reticulated ring like a sphincter and without hairs at its extremity. Antennae of the larvae 6-jointed with a very long pubescence, and with four hairs upon the last joint much longer than the others. Lateral lobes of the extremity of the abdomen with a series of three very long, frequently interlaced bristles.

ICERYA PURCHASI Maskell

(Plate IX, fig. 2)

Adult female.— Length 4 to 8 mm. Color dark orange-red, legs and antennae black, dorsal surface more or less covered with a white or yellowish white powder. The large egg sac is tinged with yellow and is longitudinally ribbed; it is a little longer than the whole body of the insect, and is filled with a loose white cottony mass containing the eggs. Over the whole surface of the body the skin is filled with circular spinnerets, each containing several openings; body clothed with short black hairs, dense at the margin of the body, forming tufts, and absent from the ventral side of the abdomen. Tarsi two-thirds the length of the tibiae; digitules of the claw very delicate and slender, and buttoned at tip.

Egg.— Red in color, true oval in shape, 0.7 mm. long.

Newly hatched larva.— Reddish, inclining to brown, in color. Antennae 6-jointed, joint 1 short and thick, joints 2, 3, 4, and 5 longer, slenderer, subcylindrical, and subequal, joint 6 larger and club-shaped. (There is sometimes an additional joint between 5 and 6.) All the joints except 1 with a few hairs; joint 6 with several, of which four are very long. Legs long and slender; tibia and tarsus with several long hairs; digitules of the tarsal claw proportionately much larger

than in the adult, bent like hooks, and buttoned at tips; tarsal digitules represented by simple hairs. The six anal bristles are very long and conspicuous, each arising from a quite prominent tubercle. Six longitudinal rows of spinnerets are seen upon the dorsum, two rows sublateral and the other four more nearly in the middle. These rows soon become confused, and are no longer distinguishable after the larvae have become somewhat grown. Alternating with the spinnerets are rows of hairs.

As the larva grows its appearance gradually changes. The outline, still oval, becomes more irregular, and its color is of a darker red, nearly brown. The six anal hairs become shorter until they are indistinguishable from the other hairs of the body, which become more abundant, especially on the abdomen, where the lateral tufts of the adult begin to appear early.

The young larva soon begins to excrete tufts of a yellow waxy matter along the dorsal surface of the body and the lateral margins. The excretion on the dorsum consists of four pairs of large tufts, while along the margin is a simple row of poorly defined smaller tufts. Between the dorsal and lateral excreted masses the body is naked, thus leaving on each side a bright red line, which contrasts strongly with the yellow excretion. Ventral surface of the body naked. From a row of large spinnerets, around the lateral edge of the body, project long delicate semi-transparent filaments, and from between the posterior pair of dorsal tufts there projects a long white waxy filament (often 10 mm. or more in length), on the end of which is usually a drop of clear fluid. This filament is very brittle, so that a slight jar will cause nearly every one on a tree to break.

The insects seem first to settle upon the leaves, preferably along the midrib, and afterwards to migrate to the twigs and branches, or even the trunk.

Habitat.— I found this species first during the summer of 1880, in a grove of 130 lime trees, owned by Mr. W. W. Stowe, at Santa Barbara, Cal. The trunks and limbs were in many cases so completely covered as to appear white, the leaves were turning yellow, and the tree was apparently dying. They had spread to surrounding orange orchards and I learn this year from Mr. G. W. Coffin, of the same place, that they are spreading with amazing rapidity.

It seems probable that it is an Australian species. The specific name which we have adopted was given this insect by Mr. Maskell, in the Transactions and Proceedings, New Zealand Institute, volume xi, page 221. It was found on a hedge of kangaroo acacia in Auckland, New Zealand, in great numbers, but upon that single hedge alone.

It is the same insect spoken of by Professor Riley, in the department report for 1878, under the name of *Dorthesia characias* Westw., where he stated that it had recently been imported into South Africa from Australia, and had become such a scourge as to attract the attention of the government. The first published notice of its appearance in this country which we have been able to find is in the California Agriculturist and Artisan for December, 1877, by Dr. A. W. Saxe, of Santa Clara, who stated it as his belief that the pest was originally brought from Australia on some plants imported by Mr. George Gordon, of Menlo Park, in 1868; and that it spread all along the coast counties. In the same article a letter from Dr. H. Behr, of San Francisco, identifies it as a species of Dorthesia.

Dr. Hagen, of Cambridge, Mass., informs me that he has seen the same species in greenhouses at Cambridge.

Genus **ORTHEZIA** Bosc.

Adult female.— Antennae 8-jointed, joints 2 and 8 longest, then 3, 4, and 5 almost equal, then 6 and 7 smaller and subequal, joint 1 thick and short, as wide as long. Legs of medium size, with the tarsi nearly half the length of the tibiae. Claw medium, with a small hair at the base on each side; no digitules on the tarsus. The body is of an elongate oval, strongly rounded behind, constricted in front, emarginate at the base of the antennae, rounded at apex, anal-genital ring large and with six hairs. The whole body in all stages covered with a calcareous laminated secretion, which, with the adult female, becomes more elongated posteriorly and forms a sac containing the eggs mixed with a fine down. Later, when the young are born, they remain in the sac until they have themselves secreted a sufficient amount of the lamellar material to cover them. This secretion is formed by hair-like spinnerets, scattered in considerable number over the whole surface of the body, and much more abundant in the perfect insect than in the larva.

Newly hatched larva.— Elongate oval, rounded in front, narrow behind. Antennae 6-jointed, joint 6 longest, a little longer than 4 and 5 together; joint 3 next to the longest. Legs and mouth parts well developed, the latter extending beyond the anterior border and having the appearance of being upside down.

Female larva.— Longer, with the sides more nearly parallel. Antennae 7-jointed, joint 7 very long, joint 3 next, joint 4 shortest; joint 7 ends in a short obtuse hair and bears eight short spine-like hairs, and, near the middle, a stronger obtuse hair. The legs are as usual, tarsi almost as long as tibiæ, pubescent.

Male larva.— What we consider (with some doubt, however) to be the male larva, is rounded, oval in shape, and is remarkable for the peculiarities of its antennae. The basal joint is very large and very long, and at its tip the rest of the antennae makes a bend. Joint 2 is almost as long as 1 but much slenderer, and bears four hairs upon its distal end and two smaller ones upon its disk; joints 3, 4, 5, and 6 are smaller and subequal, each one broadening at tip and bearing two small hairs; joint 7 is the longest of all, is a little bent, bears a very long hair at the tip, a little below it is a much smaller one, and two on each side.

Male.— Very long, with multiple eyes. The antennae are very long, filiform, each joint up to 9 with a swelling at tip; joints 1 and 2 very small, 3 very long, 4 to 8 a third shorter, subequal, 9 shorter still; all joints with a short pubescence. Thorax very long; wings a little acuminate at tip. Abdomen enlarged in the middle, bearing along each side a line of hairs, and upon the penultimate segment a band of tubular hairs which secrete a transparent caducous material. Legs long, pubescent, with a very long claw. Sexual apparatus large, forming about one-fifth the length of the abdomen.

In the collection of Professor Uhler are a number of specimens of a species of Orthezia labeled "Canada" and "Grimsby, Ontario." One specimen bears the label "On Golden Rod." These specimens seem, on superficial examination, to be specifically identical with a type specimen of Walker's *Orthezia americana*, which is also in Professor Uhler's collection. I have found immature specimens of what may be the same species upon the common burdock (*Arctium officinale*) at Ithaca, N. Y. (Plate IX, fig. 3.)

EXPLANATION OF PLATES

PLATE III (Original)

FIG. 1.—*Aspidiotus aurantii* Maskell. 1, Scales on leaves of orange, natural size; 1*a*, adult male, much enlarged; 1*b*, scales of female, enlarged; 1*c*, scale of male, enlarged.

FIG. 2.—*Aspidiotus ficus* (Riley MSS.). 2, Scales on leaves of orange, natural size; 2*a*, scale of female, enlarged; 2*b*, scale of male, enlarged; 2*c*, young larva; 2*d*, 2*e*, and 2*f*, different stages in the formation of the scale.

PLATE IV (Original)

FIG. 1.—*Aspidiotus nerii* Bouché. 1, Scales on leaves of acacia, natural size; 1*a*, adult male, enlarged; 1*b*, scale of male, enlarged; 1*c*, scale of female, enlarged.

FIG. 2.—*Ceroplastes Floridensis* n. sp. 2, Adult and young females on ilex, natural size; 2*a*, young female, enlarged; 2*b*, adult female, enlarged.

FIG. 3.—*Ceroplastes cirripediformis* n. sp. 3, Adult females, natural size; 3*a*, female, enlarged.

PLATE V (Original)

FIG. 1.—*Diaspis rosae* (Sand.). 1, Scales on rose, natural size; 1*a*, scale of female, enlarged; 1*b*, scale of male, enlarged.

FIG. 2.—*Diaspis carueli* Targ.-Tozz. 2, Scales on juniper, natural size; 2*a*, scale of female, enlarged; 2*b*, scale of male, enlarged.

FIG. 3.—*Chionaspis euonymi* n. sp. 3, Scales on euonymus, natural size; 3 *a*, scale of male, enlarged; 3*b*, scale of female, enlarged.

PLATE VI (Original)

FIG. 1.—*Chionaspis furfurus* (Fitch). 1, Scales on pear, natural size; 1*a*, scale of male, enlarged; 1*b*, adult male, enlarged; 1*c*, scale of female, enlarged.

FIG. 2.—*Chionaspis pinifoliae* (Fitch). 2, Scales on *Pinus strobus*, natural size, leaves stunted; 2*a*, leaves of *P. strobus* not stunted by coccids; 2*b*, scale of female, usual form, enlarged; 2*c*, scale of female, wide form, enlarged; 2*d*, scale of male, enlarged.

PLATE VII (Original)

FIG. 1.—*Mytilaspis citricola* (Pack.). 1, Scales on orange, natural size; 1*a*, scale of female, dorsal view, enlarged; 1*b*, scale of female with ventral scale and eggs, enlarged; 1*c*, scale of male, enlarged.

FIG. 2.—*Mytilaspis Gloverii* (Pack.). 2, Scales on orange, natural size; 2*a*, scale of female, dorsal view, enlarged; 2*b*, scale of male, enlarged; 2*c*, scale of female with ventral scale and eggs, enlarged.

PLATE VIII (Original)

FIG. 1.—*Lecanium oleae* Bernard. 1, Adult females on olive, natural size; 1*a*, female, enlarged.

FIG. 2.—*Lecanium hesperidum* Linn. Adult females on orange, natural size.

FIG. 3.—*Lecanium hemisphaericum* Targ. 3, Adult females on orange, natural size; 3*a*, adult female, enlarged.

PLATE IX (Original)

FIG. 1.—*Kermes* sp., on *Quercus agrifolia*. Adult females on stem; immature males on leaves.

FIG. 2.—*Icerya purchasi* Maskell. Females, adult and young, on orange.

FIG. 3.—*Orthezia* sp.

PLATE X (Original)

FIG. 1.—*Rhizococcus araucariae* (Maskell). 1, Sacs of male and female on Norfolk Island pine, natural size; 1*a*, adult male, enlarged; 1*b*, caudal extremity of male with excretion removed. 1*c*, the same of female; 1*d*, adult female, enlarged; 1*e*, tarsus of male, showing digitules; 1*f*, leg of female; 1*g*, spinnerets of female; 1*h*, antenna of female.

FIG. 2.—*Rhizococcus quercus* n. sp. 2, Sacs of male and female on *Quercus virens*, natural size; 2*a*, spinnerets of female, enlarged; 2*b*, leg of female, enlarged.

PLATE XI (Original except Fig. 1)

FIG. 1.—*Dactylopius adonidum* Linn. (after Signoret). 1, Lateral lobe of the abdominal extremity of female; 1*a*, antenna of female; 1*b*, antenna of male; 1*c*, leg of female; 1*d*, anal ring with six hairs.

FIG. 2.—*Dactylopius longifilis* n. sp. Female, enlarged.

FIG. 3.—*Dactylopius destructor* n. sp. Female, enlarged.

FIG. 4.—*Parlatoria pergandii* n. sp. 4*a*, scale of female, enlarged; 4*b*, scale of male, enlarged.

FIG. 5.—*Parlatoria zizyphi* Lucas. Scale of female, enlarged.

FIG. 6.—*Pulvinaria* on grape. Female, natural size.

FIG. 7.—*Fiorinia camelliae* n. sp. Scale of female, enlarged.
FIG. 8.—*Chionaspis quercus* n. sp. Scale of female, enlarged.
FIG. 9.—*Asterodiaspis quercicola* (Bouché). Enlarged.
FIG. 10.—*Mytilaspis* [———].

PLATE XII (Original)

FIG. 1.—*Aspidiotus aurantii* Maskell.
FIG. 2.—*Aspidiotus ficus* (Riley MSS.).
FIG. 3.—*Aspidiotus perseae* n. sp.
FIG. 4.—*Aspidiotus obscurus* n. sp.
FIG. 5.—*Aspidiotus tenebricosus* n. sp.
FIG. 6.—*Aspidiotus rapax* n. sp.
FIG. 7.—*Aspidiotus perniciosus* n. sp.
FIG. 8.—*Aspidiotus convexus* n. sp.

PLATE XIII

FIG. 1.—*Aspidiotus aurantii* Maskell.
FIG. 2.—*Aspidiotus ficus* (Riley MSS.).
FIG. 3.—*Aspidiotus perseae* n. sp.
FIG. 4.—*Aspidiotus obscurus* n. sp.
FIG. 5.—*Aspidiotus tenebricosus* n. sp.

PLATE XIV

FIG. 1.—*Aspidiotus cydoniae* n. sp.
FIG. 2.—*Aspidiotus juglans-regiae* n. sp.
FIG. 3.—*Aspidiotus ancylus* Putnam.
FIG. 4.—*Aspidiotus uvae* n. sp.

PLATE XV

FIG. 1.—*Aspidiotus nerii* Bouché.
FIG. 2.—*Aspidiotus* (?) *pini* n. sp.
FIG. 3.—*Diaspis carueli* Targ.-Tozz.
FIG. 4.—*Diaspis ostreaeformis* Curtis.

PLATE XVI

FIG. 1.—*Aspidiotus uvae* n. sp.
FIG. 2.—*Aspidiotus* (?) *pini* n. sp.
FIG. 3.—*Chionaspis furfurus* (Fitch).
FIG. 4.—*Chionaspis pinifoliae* (Fitch).
FIG. 5.—*Chionaspis salicis* (Linn.).
FIG. 6.—*Chionaspis ortholobis* n. sp.

PLATE XVII

FIG. 1.—*Diaspis rosae* (Sand.).
FIG. 2.—*Chionaspis euonymi* n. sp.
FIG. 3.—*Chionaspis furfurus* (Fitch).
FIG. 4.—*Chionaspis nyssae* n. sp.

PLATE XVIII

FIG. 1.—*Chionaspis pinifoliae* (Fitch).
FIG. 2.—*Chionaspis quercus* n. sp.
FIG. 3.—*Mytilaspis citricola* (Pack.).
FIG. 4.—*Mytilaspis Gloverii* (Pack.).

PLATE XIX

FIG. 1.—*Chionaspis ortholobis* n. sp.
FIG. 2.—*Mytilaspis pomorum* Bouché.
FIG. 3.—*Parlatoria pergandii* n. sp.
FIG. 4.—*Fiorinia camelliae* n. sp.

PLATE XX

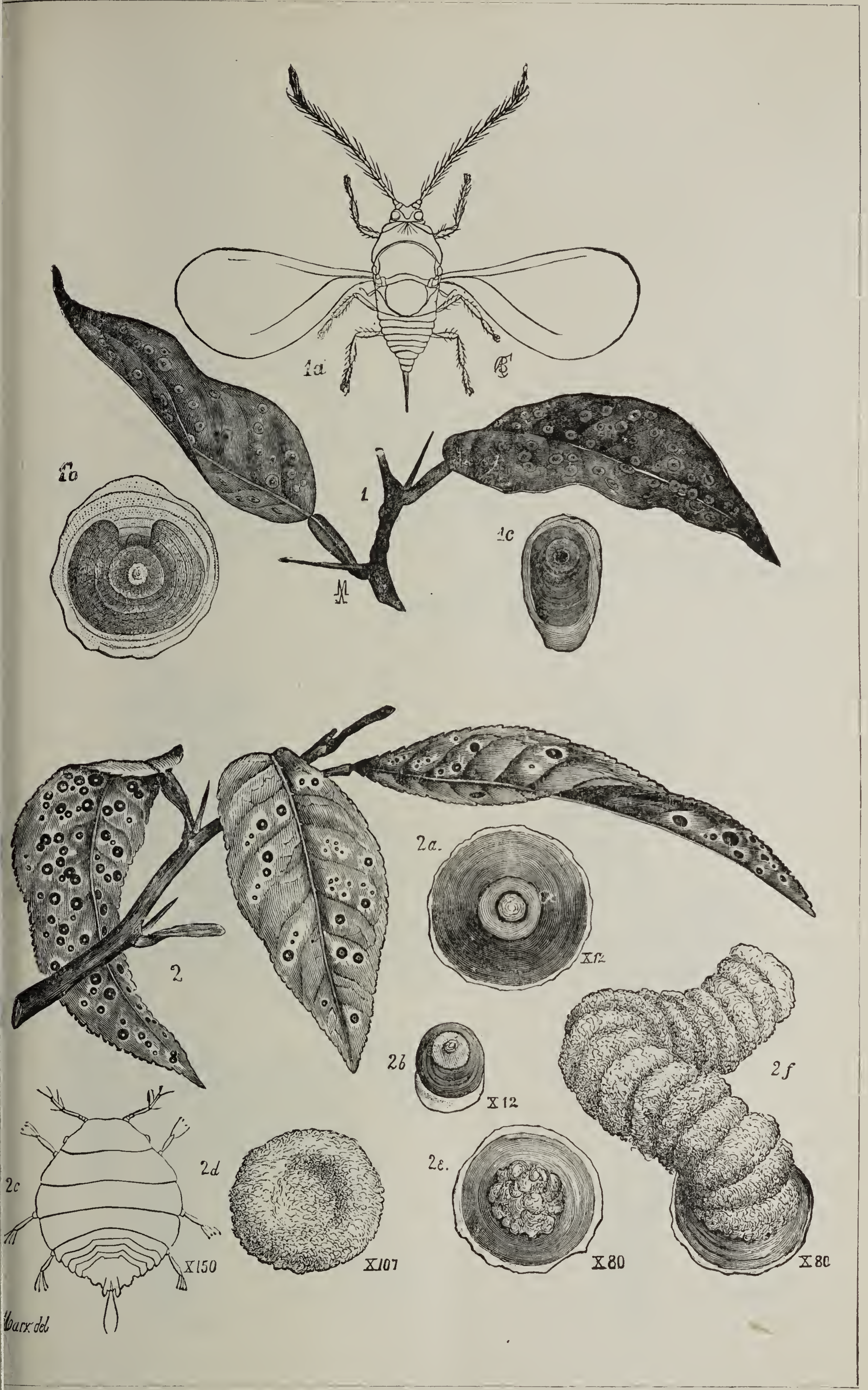
FIG. 1.—*Mytilaspis pandanni* n. sp.
FIG. 2.—*Mytilaspis pandanni* n. sp.
FIG. 3.—*Mytilaspis citricola* (Pack.).
FIG. 4.—*Fiorinia camelliae* n. sp. Dorsal view.
FIG. 5.—*Parlatoria pergandii* n. sp.

PLATE XXI

FIG. 1.—*Mytilaspis Gloverii* (Pack.).
FIG. 2.—*Aspidiotus ancylus* Putnam.
FIG. 3.—*Aspidiotus ficus* (Riley MSS.)
FIG. 4.—*Aspidiotus ancylus* Putnam.
FIG. 5.—*Diaspis rosae* (Sand.).
FIG. 6.—*Diaspis carueli* Targ.-Tozz.
FIG. 7.—*Aspidiotus* (?) *pini* n. sp.
FIG. 8.—*Parlatoria pergandii* n. sp.

PLATE XXII

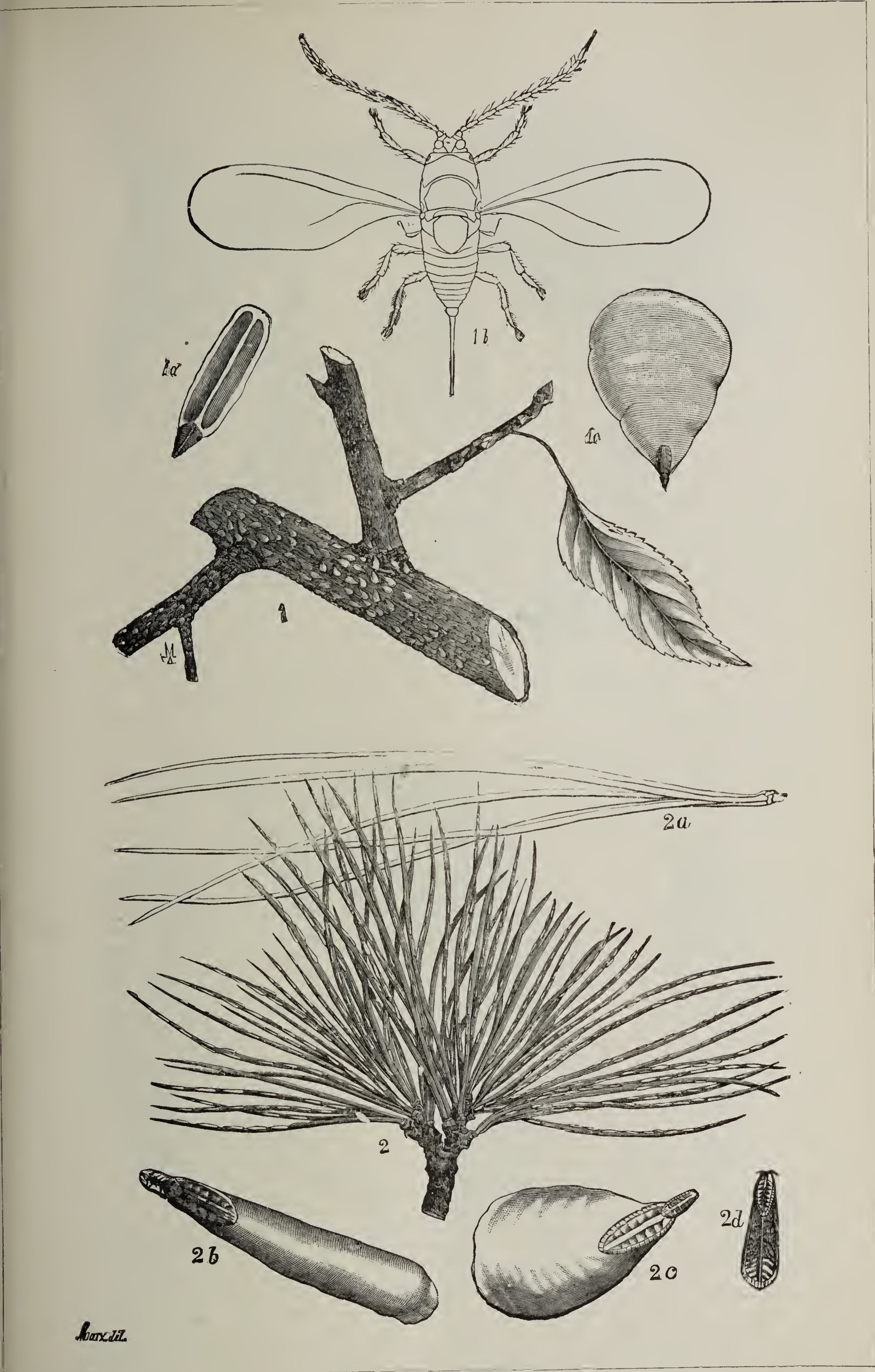
FIG. 1.—*Dactylopius longifilis* n. sp. Male, enlarged.
FIG. 2.—*Dactylopius destructor* n. sp. Male, enlarged.



(Plate XI, Cornell series)

(Plate XII, Cornell series)

(Plate XIII, Cornell series)



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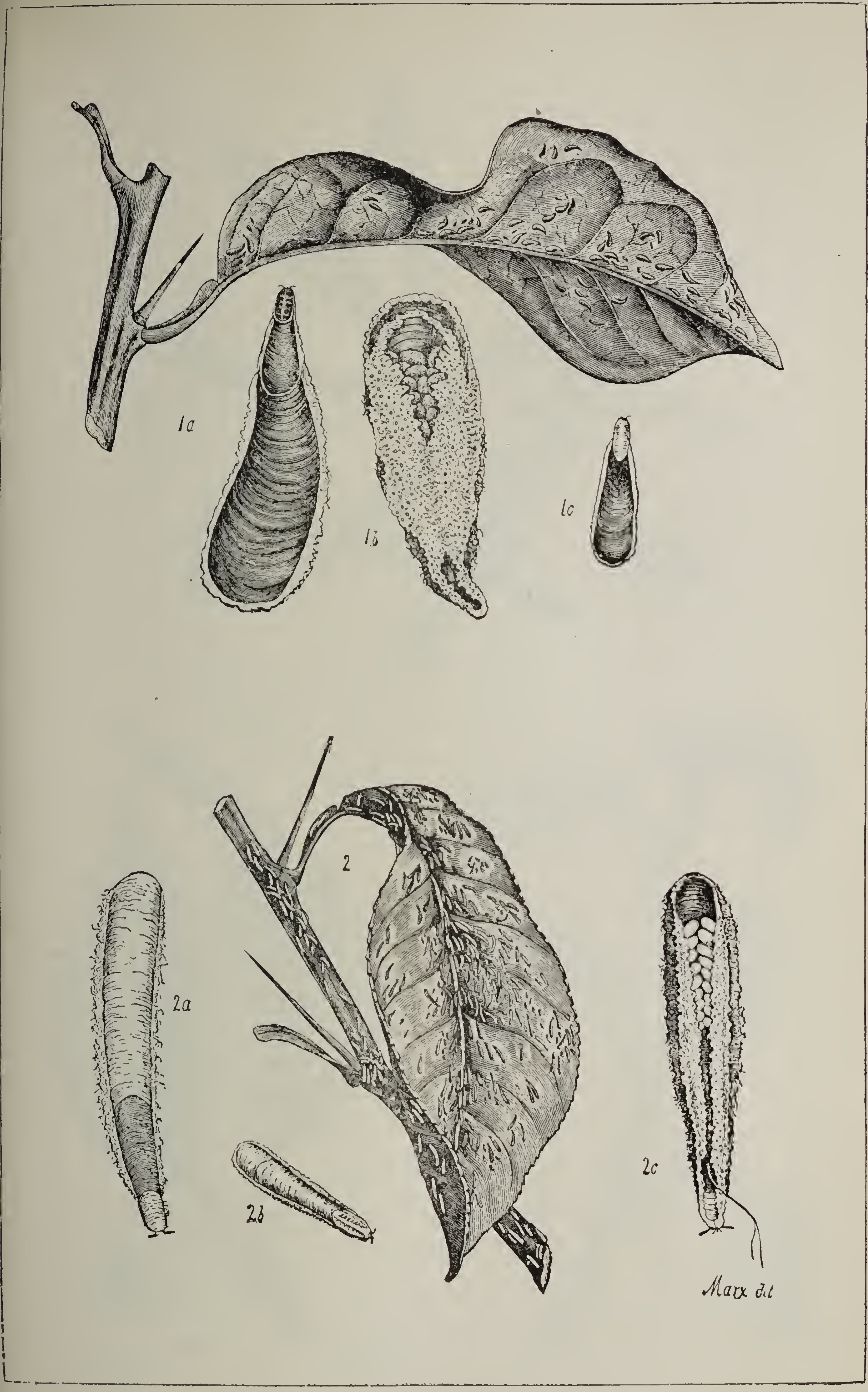
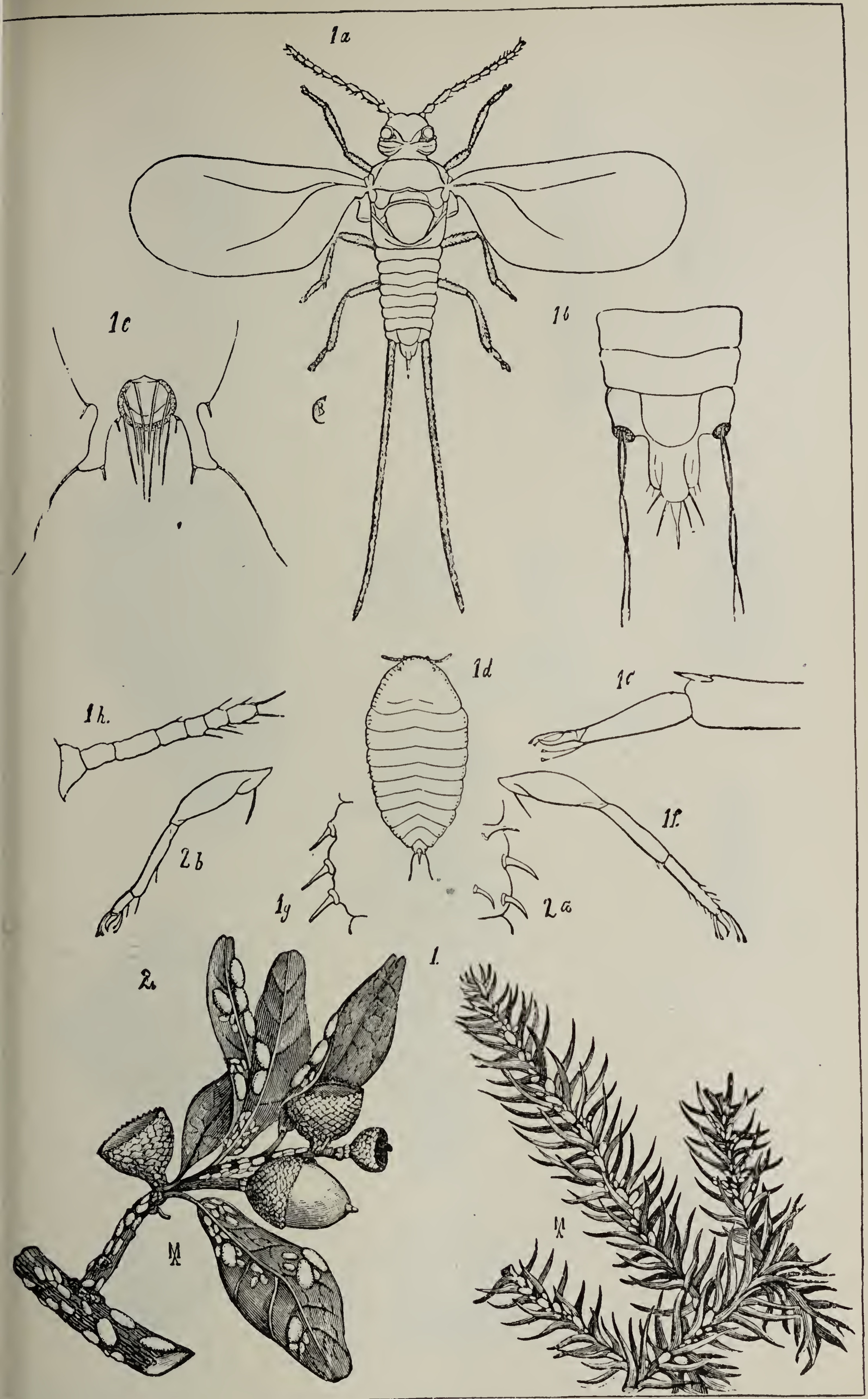


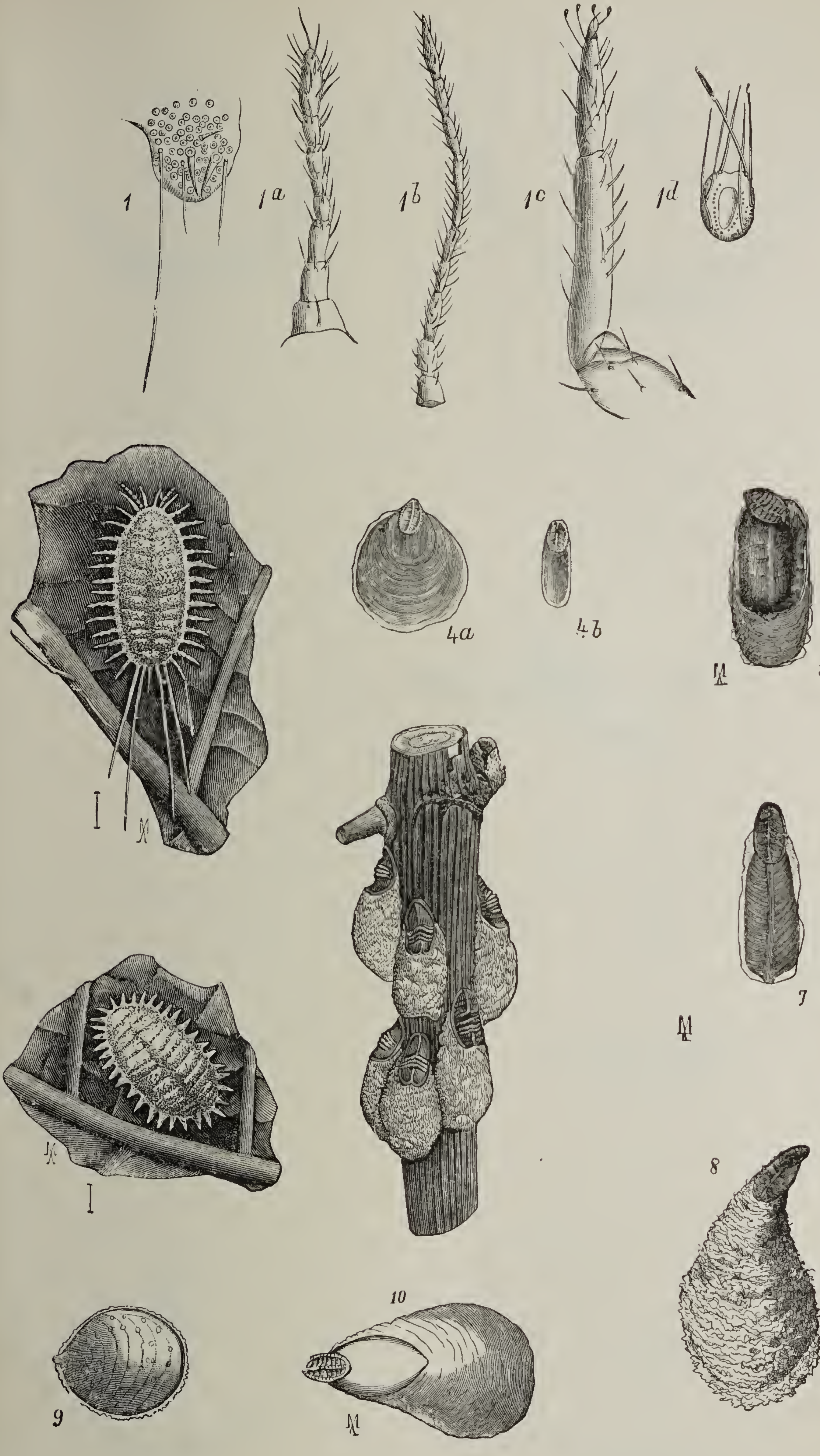
(Plate XV, Cornell series)

(Plate XVI, Cornell series)

(Plate XVII, Cornell series)



(Plate XVIII, Cornell series)



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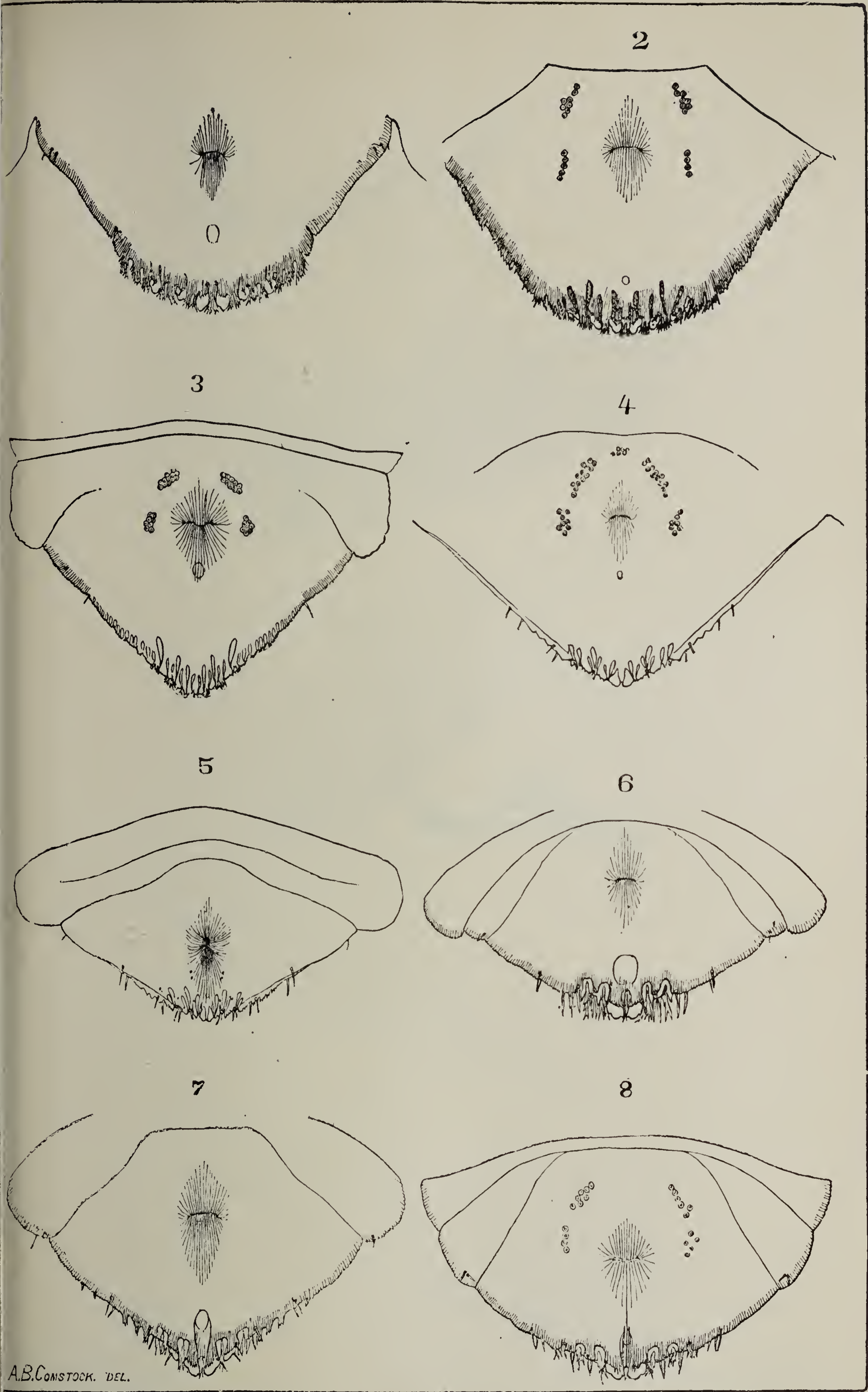
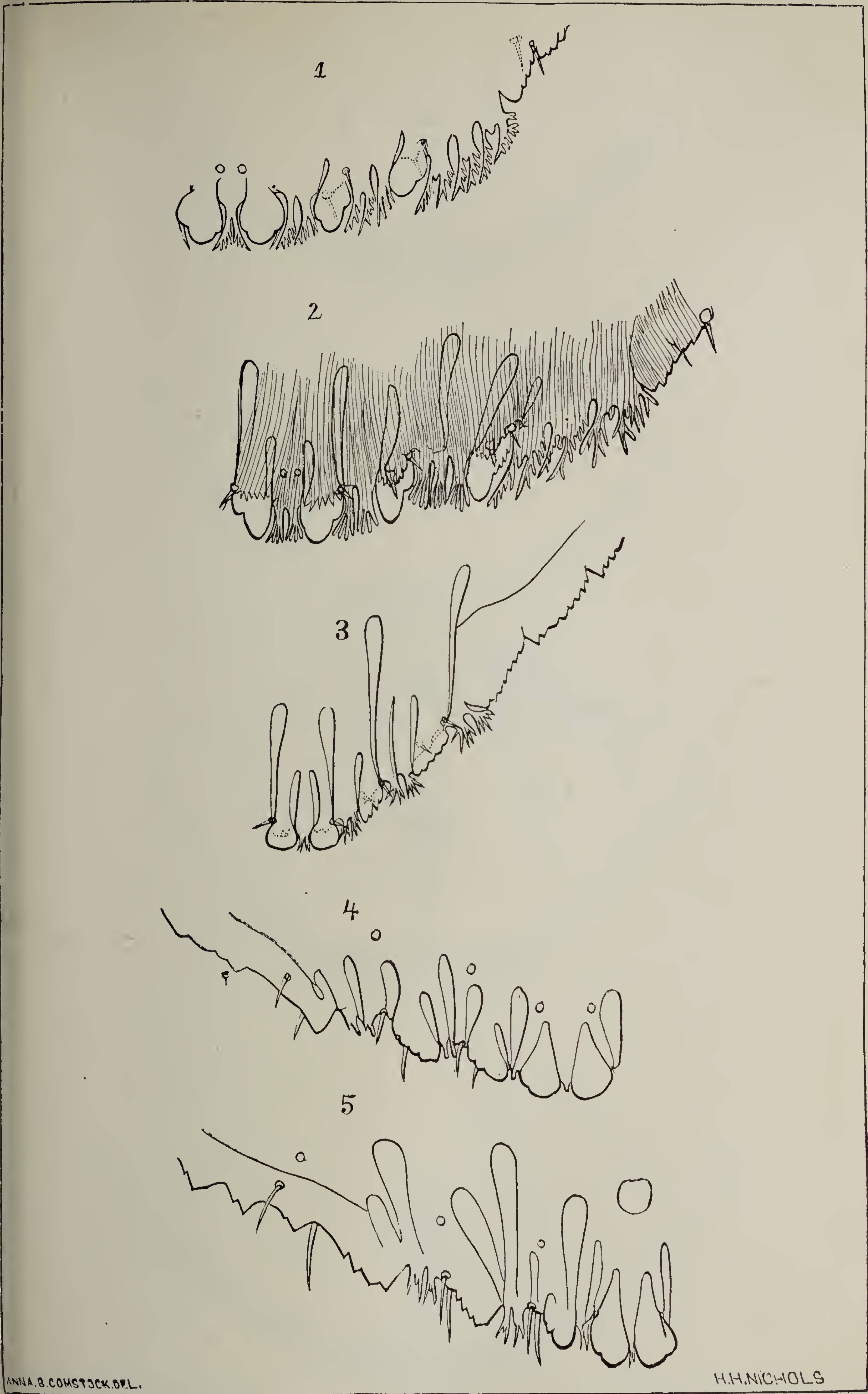


(Plate XX, Cornell series)



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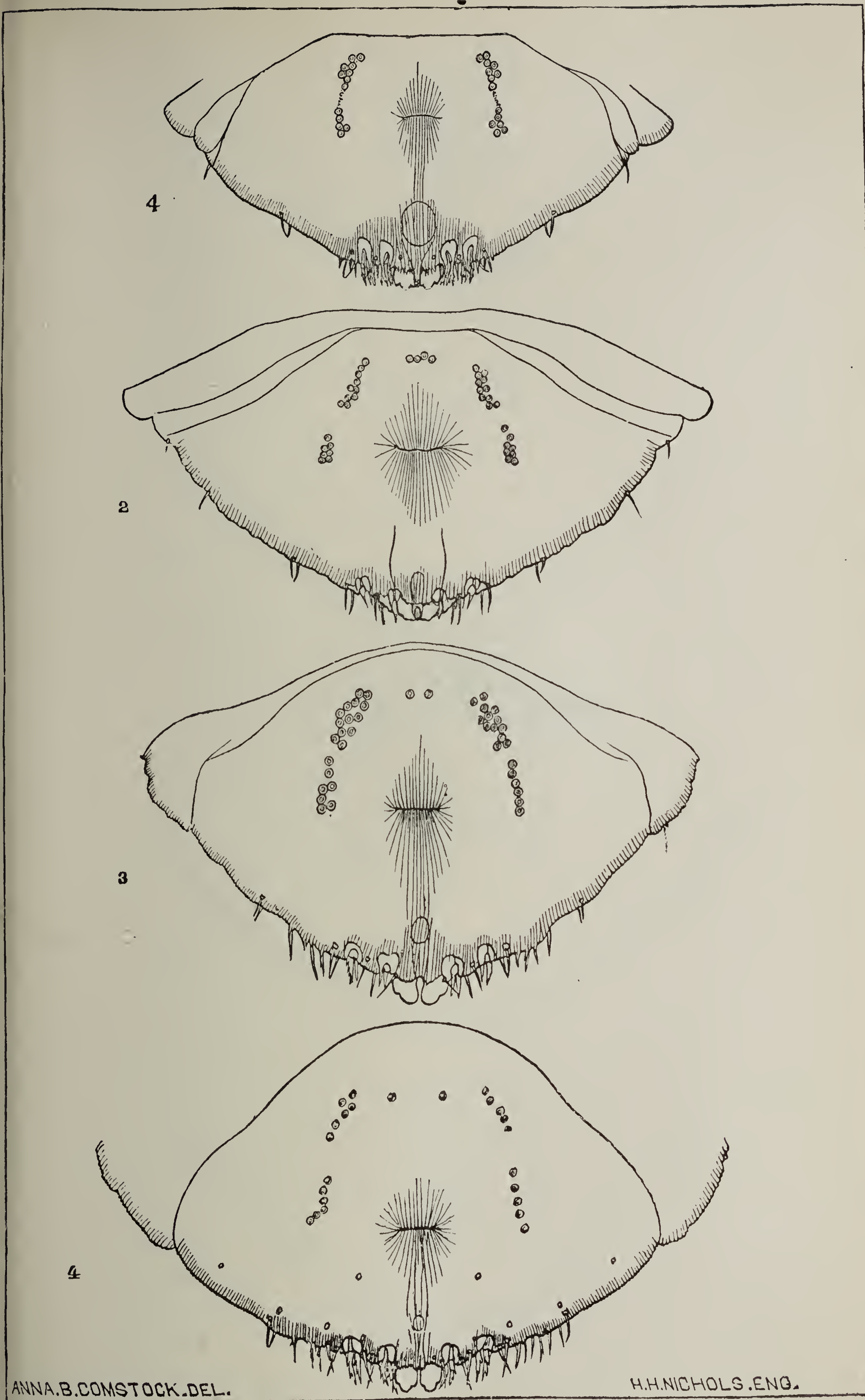

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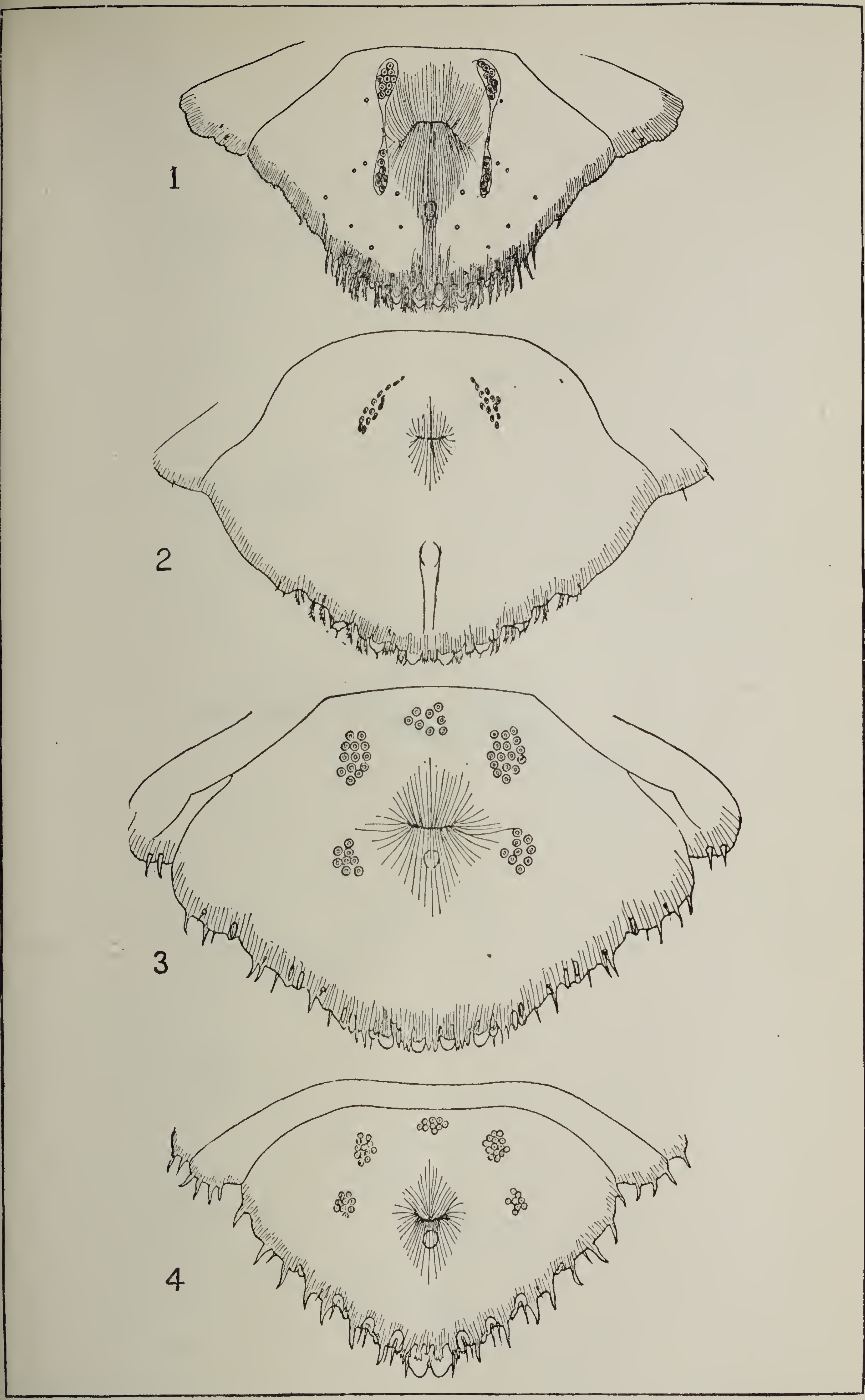

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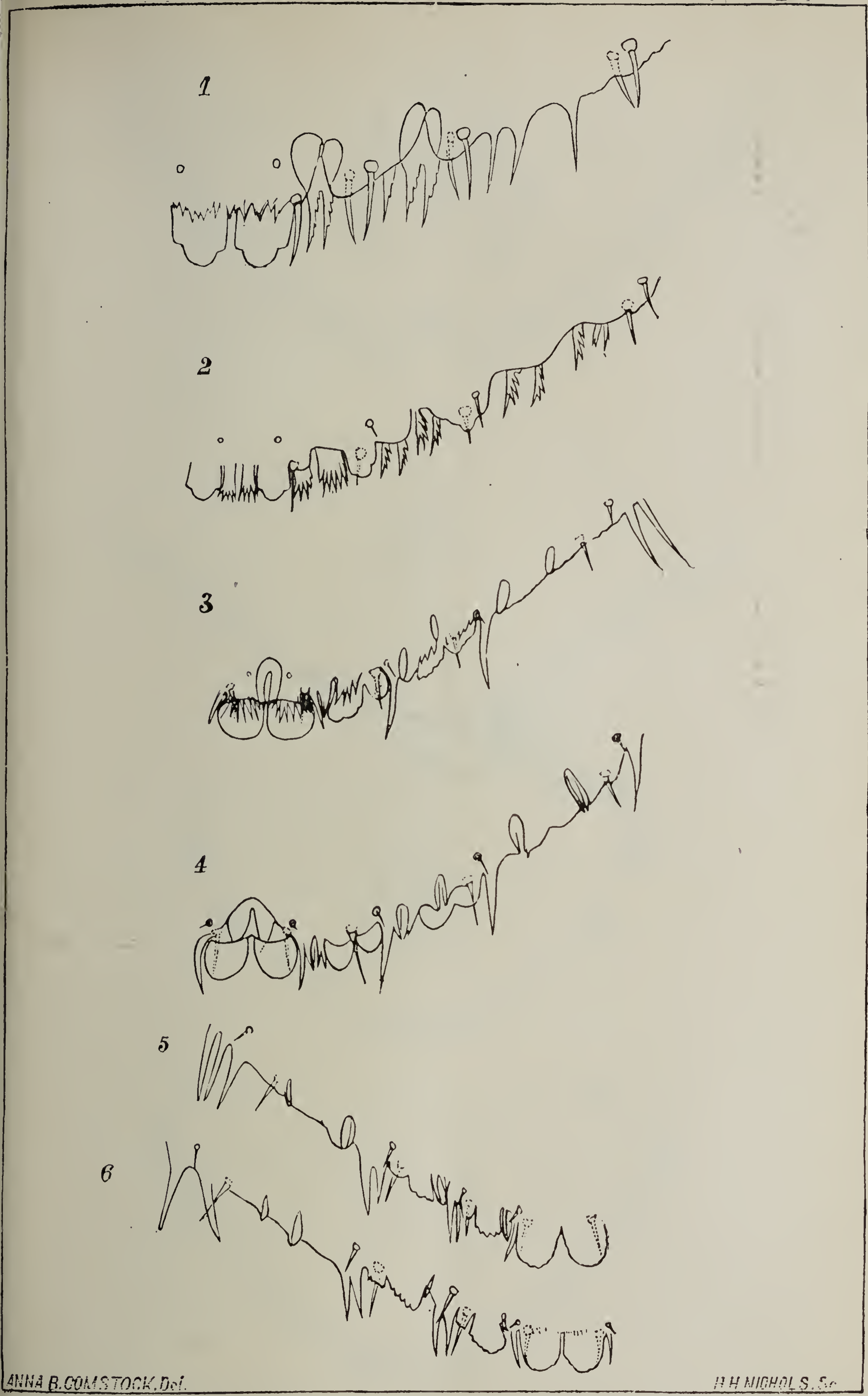

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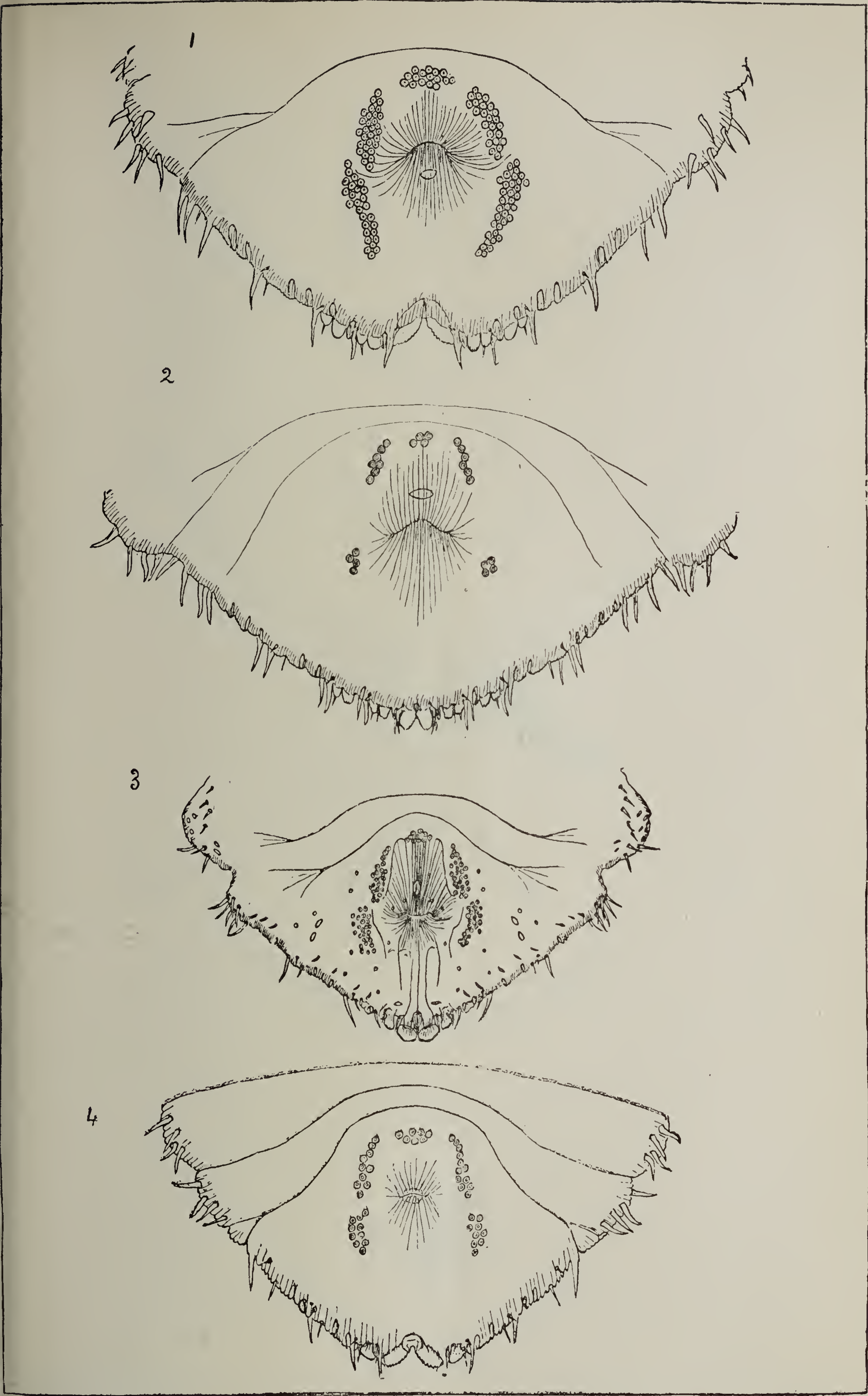

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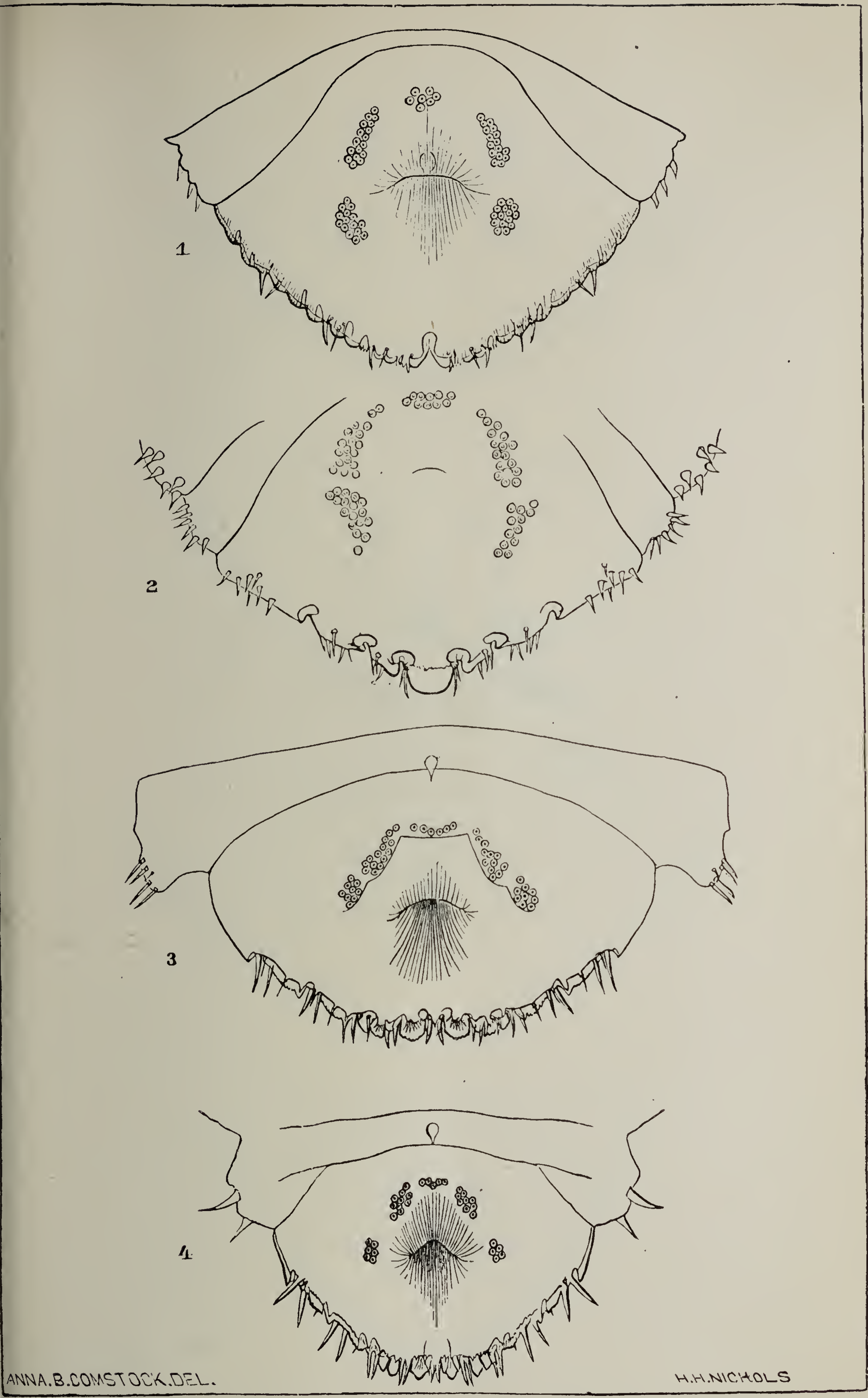

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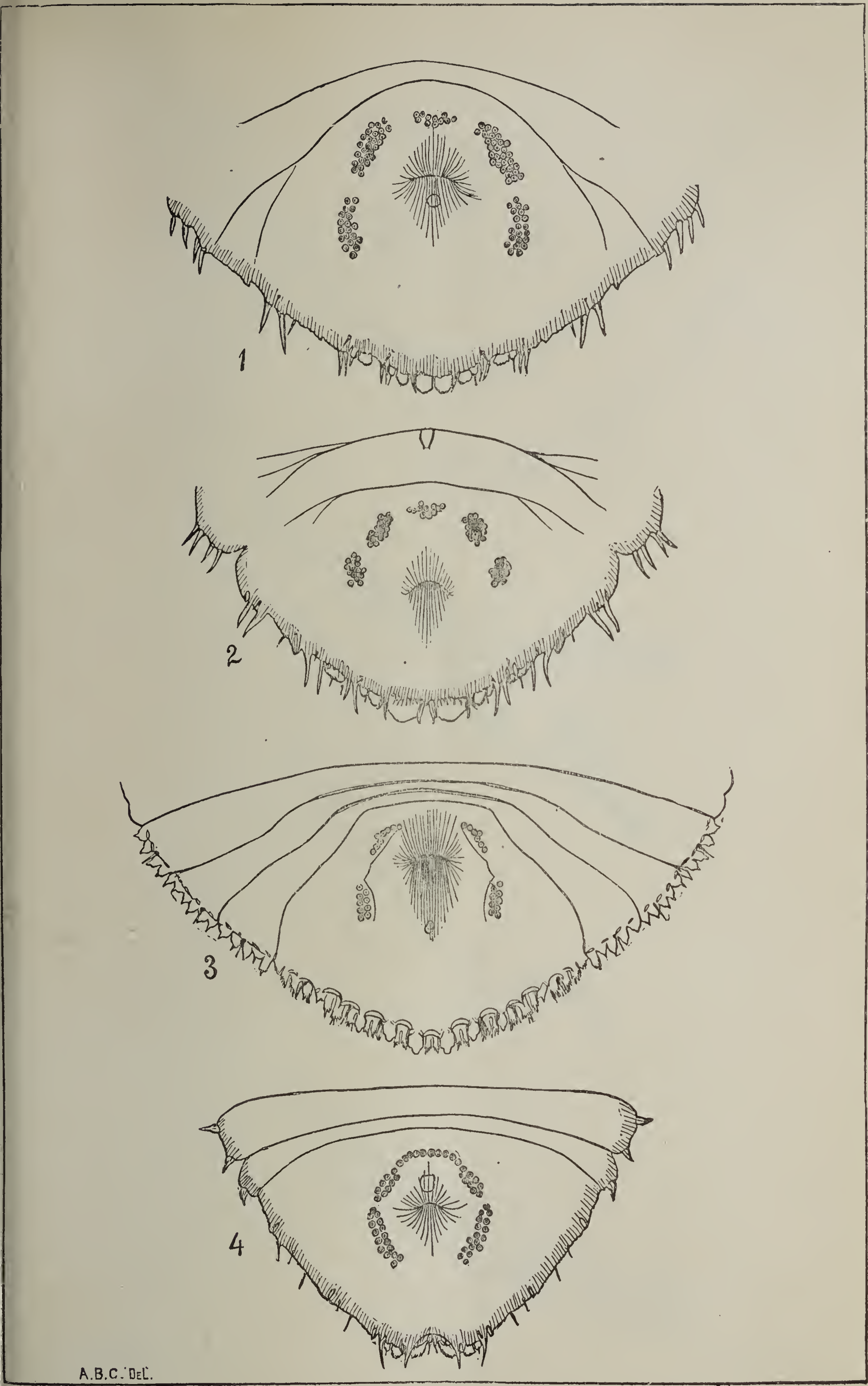

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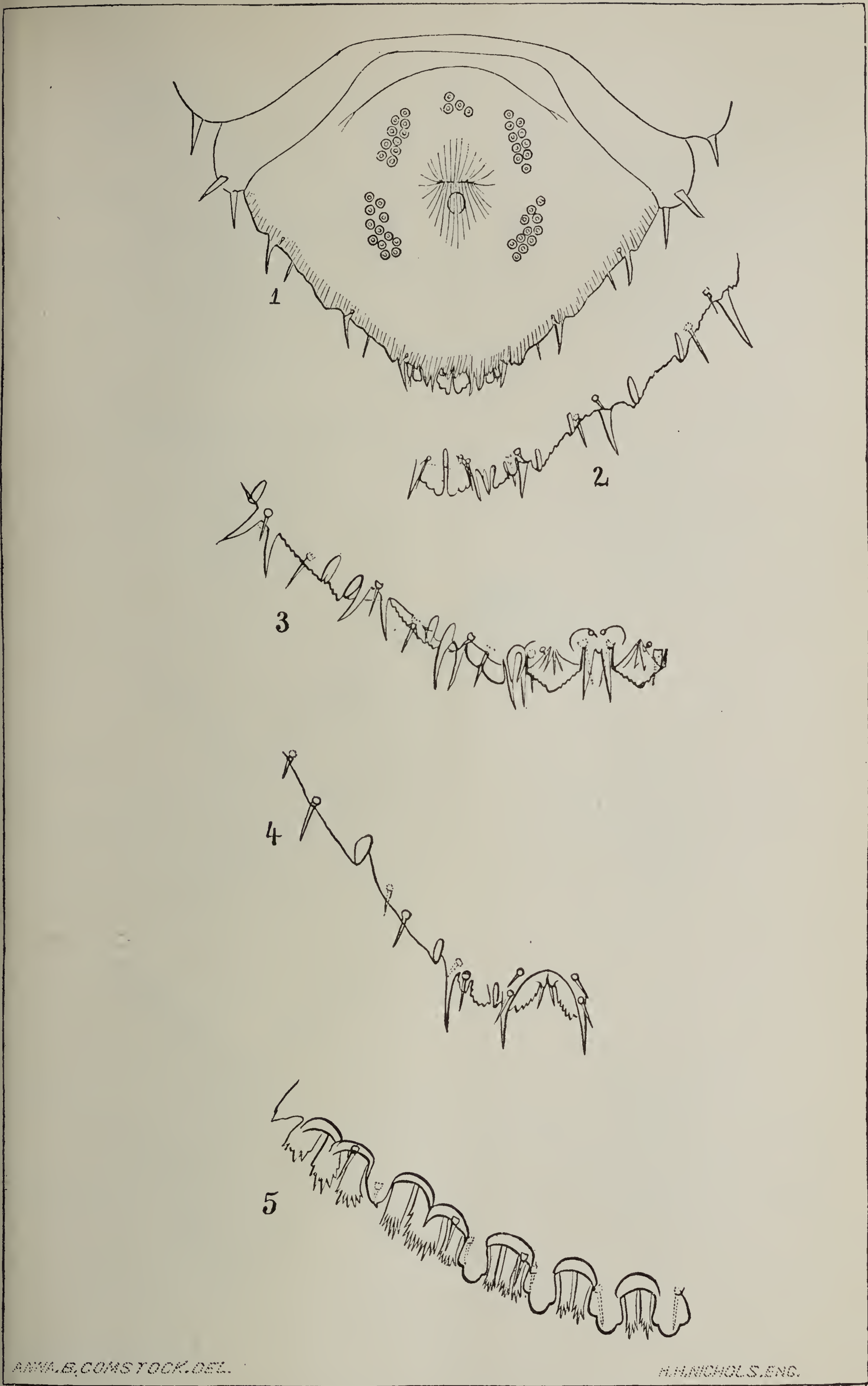

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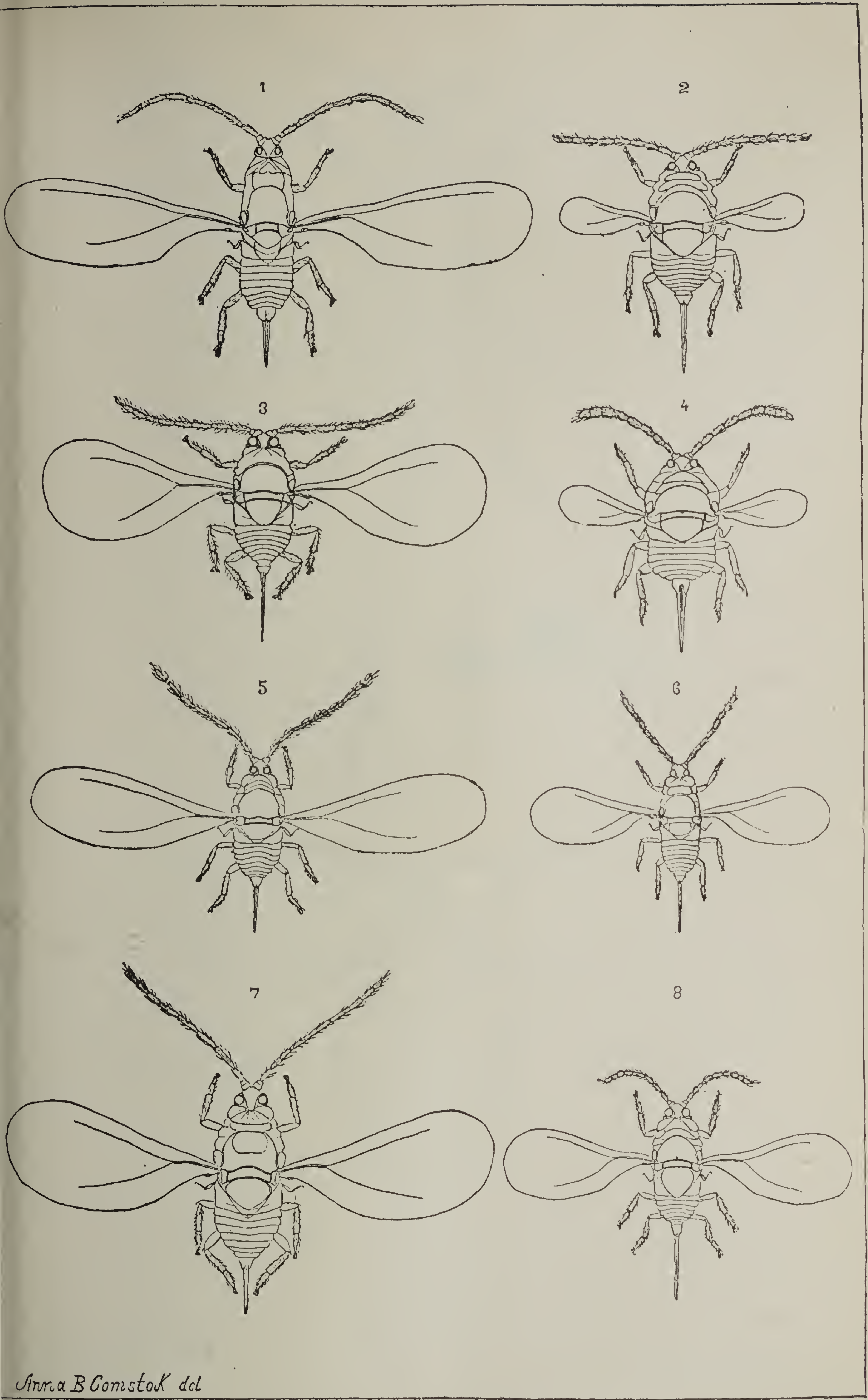
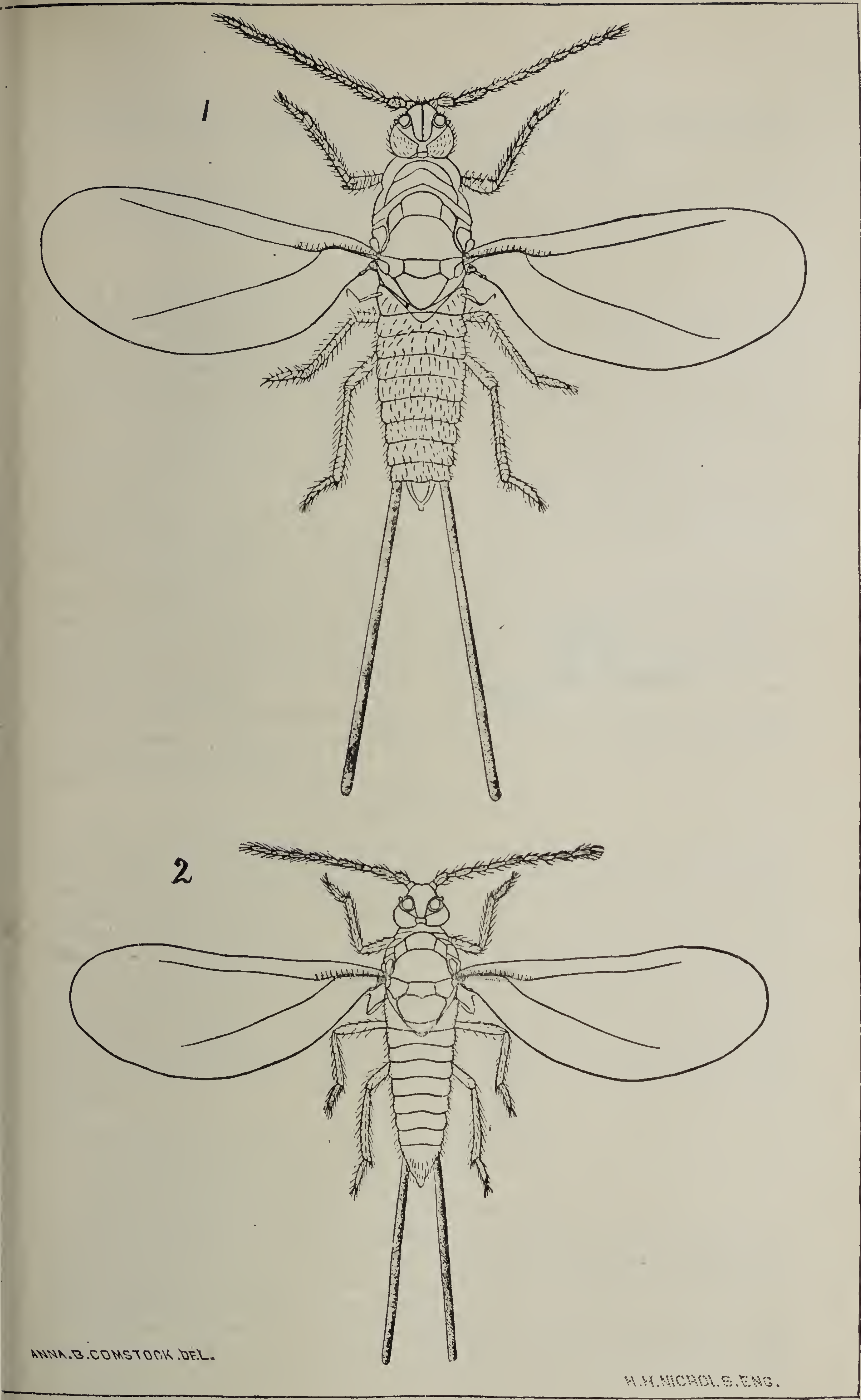


(Plate XXIX, Cornell series)



(Plate XXX, Cornell series)

REPORT OF THE ENTOMOLOGIST, UNITED STATES DEPARTMENT OF AGRICULTURE

(The following six pages and two plates are from the Report of the Commissioner of Agriculture for the years 1881 and 1882)

LAC INSECTS

It is now more than one hundred years since *Carteria lacca,* the insect which produces the lac of commerce, was first described.* Since that time many articles have been written respecting it. Owing to the importance in the industrial arts of shellac and the lac dyes, the origin of these substances is discussed in nearly all of the larger cyclopedias; and the list of the memoirs on this subject in the scientific journals is a long one. Notwithstanding this, an examination which I have made of the matter convinces me that the subject is not yet well understood.

I was led to study this insect by the fact that I have met with two other species of lac insects which are as yet undescribed. The result of this study shows that although the two new lac insects are American they are congeneric with the Asiatic species.

The opportunity of comparing three species of this important genus has enabled me to make some interesting observations, but owing to lack of time I can now give only a general statement of the results of my studies. I am led to make this statement now, as the knowledge of the fact that true lac insects occur in this country may prove of economic importance.

The genus Carteria was established by Signoret† for the lac insect of commerce. The two undescribed lac insects agree with this one in the following characters:

Genus **CARTERIA** Signoret

Body of the adult female sac-like in form, with no legs, and imbedded in a mass of the substance known as lac. The caudal end of the body is furnished with three prominent tubercles; one, the largest, consists of the caudal segment of the body and is terminated by the anal ring; each of the others bears at its distal extremity a perforated plate, presumably the organ through which the lac is excreted; near the base of each of the lac tubes is a large spiracle. In the triangular space inclosed by the three tubercles described is a fourth tubercle which bears a very prominent spine-like organ. The anal ring consists of several plates, which are perforated by many openings; the anal ring bears ten hairs, and is at least partially surrounded by a series of toothed plates and spines.

CARTERIA LACCA (Kerr) (Plate XIX, figs. 2–2*g*)

Coccus lacca Kerr. Phil. Trans., 1781, 374.
Coccus ficus Fabr. Mantissa, 1787, II, 319.
Carteria lacca (Kerr) Signoret. Essai, 1874, 101.

From a quantity of commercial stick-lac purchased in New York I obtained specimens of an insect which I have no doubt is the *Coccus* (*Carteria*) *lacca* of authors. From these specimens the following description and accompanying figures were drawn.

The best specimens of this lac are in the form of an incrustation from one-fourth inch to three-eighths inch in thickness upon small twigs

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* James Kerr, Philosophical Transactions, 1781, 384.
† Essai, 1874, p. 101.

(Plate XIX, fig. 2). This incrustation is filled with elongated cells. The longer axis of each cell is at right angles to the twig, and in each case the end of the cell next the twig is small, while the outer end is considerably enlarged. In well-preserved specimens three tubular openings may be seen extending from the outer end of each cell through the incrustation to the open air, and in each cell may be found the shriveled remains of an insect, which, when alive, evidently nearly filled the cell and determined its form.

By soaking the insects in water they may be made to swell out, and thus the natural form of the body be ascertained. This is represented at figure 2*a*. The cephalic end is small, and, in addition to mouth parts of the form characteristic of the Coccidae, is furnished with a pair of fleshy appendages (Fig. 2*d*). The body enlarges gradually toward the caudal end. This end is of the peculiar form described above in the characterization of the genus. In a word, the shape of the body is that of a jug with three necks and a pointed bottom, the cephalic end forming the bottom. Each of the neck-like prolongations of this jug-shaped body fits into one of the three tubular openings of the cell. One of these openings is larger than the others; this is the one occupied by the anal tubercle.

The anal tubercle consists of the whole of the last segment of the body, and a part of the penultimate segment (Fig. 2*e*). The anal ring bears ten hairs and consists of several plates (Fig. 2*f*). The hairs of the anal ring are spine-like. Each is curved outward near the middle of its length, and each one is hollow and situated over a large opening in the plate which bears it. There are also many smaller openings distributed evenly over the surface of the plates.

There is a fringe of notched plates and spines on that side of the segment which is toward the lac tubes (Figs. 2*e* and 2*g*). I have been unable to trace any tracheæ extending to the numerous openings with which the lac tubes are furnished; but the distal extremity of each tubercle contains many tubular glands, which in some instances I have traced to these openings. The structure of these organs is represented at figure 2*b*.

There are four spiracles, a large one at the base of each of the lac tubercles, and a pair of smaller ones near the head end of the body. Evidently the air must have free access to the cell, else these spiracles would be of little use. The air probably enters through the opening made by the caudal segment. In all the specimens which I have examined, in which the insect was unbroken, the lac tubes were within the corresponding tubular openings of the cell, but in no instance have I found the anal tubercle in the third opening. In each case it had been withdrawn into the cell, and occupied a position just below the anal opening (Fig. 2*a*). This withdrawal may be due to the shrinking of the body after death; but the fact that it is always the anal tubercle that is withdrawn, and not either of the others, indicates that during life this tubercle cannot be permanently fixed in its opening. The withdrawal of the anal tubercle at intervals would admit the air to the cell, and thus provide for respiration. The peculiar bending of the hairs of the anal ring is such as would facilitate the pushing of the anal tubercle into the opening after it had been withdrawn.

I have been unable to ascertain the function of the large spine. As these insects are viviparous the spine cannot be an ovipositor. The only author who I find makes mention of it is Gernet,* who simply

* Einiges ueber *Coccus lacca* und dessen Parasiten, *Moskau*, 1863.

states that there exists midway between the three tubercles a small, thickened spine, which appears to be nothing else than an enlarged bristle of the last, or next to the last, segment of the abdomen. He also states that sometimes there are two of these spines, and figures a female with two. This is undoubtedly an error.

The fullest account which has been published respecting this insect is that of H. J. Carter,* in whose honor the genus was named. Mr. Carter's memoir is a very important one, but he has fell into some errors. From his account it is evident that the insect, like many others of the Coccidae, excretes considerable masses of apparently woolly matter. This matter is probably excreted by spinnerets upon each of the three caudal tubercles, and projects from each of the three openings in the cell. The remains of these threads of excretion may sometimes be seen in the stick-lac as it reaches us, but the greater part of them are brushed or blown away. Carter believed these threads to be external tracheæ, and he figured internal tracheæ communicating with them. He even represents "tufts of tracheæ" projecting from the anus. He appears to have overlooked entirely the true spiracles, and believed the paired tubercles to be simply for respiration. No mention is made of the spine, and in the description of the male the caudal threads of excretion are spoken of as tracheæ.

Carteria larreæ, new species (Plate XX, figs. 1–1*h*)

The creosote plant (*Larrea mexicana*) is a shrub growing, from 4 to 6 feet high, very abundantly in certain regions in the southwestern portion of the United States and in Mexico. It is said to form

> a dense and almost impassable scrub, particularly on the borders of the Colorado desert, where its luxuriant growth puts a stop to the drifting sand. It is a sure sign of a sterile soil, for wherever it flourishes little else can be found, and although it gives the scenery a beautiful, verdant appearance, its strong, creosote-like odor renders it so repulsive that no animal will touch it. Moreover, as it can scarcely be made to burn, it is useless even for the purpose of fuel. The resinous matter to which the odor is due abounds in all parts of the plant. The Pimos Indians collect and form it into balls, which they kick before them as they journey from one point to the other of their trail.†

This extract gives, in a few words, what was until recently the accepted belief respecting American lac. But in April, 1880, Mr. J. M. Stillman presented to the California Academy of Sciences ‡ a very able and important paper on this subject, in which he showed that the so-called resinous exudation of the creosote plant was apparently identical with the gum-lac from India. Mr. Stillman also gave very cogent chemical and physical reasons for believing that in each case the lac is excreted by the insects found in it instead of being simply an exudation of the plant caused by the punctures of these insects, as is stated in nearly all of the writings on the subject. The presence of the large and complicated excreting organs, which I have termed lac tubes in each of the species described in this paper, confirms this conclusion.

A study of the insect which produces the American lac shows that it is specifically distinct from *Carteria lacca*. I therefore propose the name *C. larreæ* for it. In all the specimens which I have seen, the incrustation of lac is not as thick as that produced by *C. lacca*, being rarely more than one-eighth of an inch in thickness. And the masses excreted

* Annals and Magazine of Natural History, 1861, p. 1–10.

† A. Smith, in the Treasury of Botany.

‡ See American Naturalist, Vol. XIV, p. 782.

by the different individuals are not crowded together so compactly as in the Indian species, but preserve a more or less globular form. (See Plate XX, fig. 1.) In the case of isolated masses there is a tendency to a six-lobed condition.

This species is the smallest of the three known lac insects, the adult female being but little more than 2 mm. (.08 inch) in diameter. The body is nearly globular in outline, with, however, prominent lac tubes and anal tubercle. The caudal spiracles are also prominent. Figure 1*a* represents an individual from which the greater part of the lac has been dissolved. A specimen treated in this way served to show the general form of the body. The structure of the different organs was studied upon specimens which had been boiled in caustic potash, and from which in this way all the excretion had been removed. Figure 1*d* represents the anal tubercle with the anal ring and fringe. Figure 1*f* shows a part of the fringe enlarged. One of the lac tubes with its perforated plate is represented at figure 1*g*, the corresponding spiracle at figure 1*h*, and the spine at figure 1*e*. Scattered over the surface of the body are groups of organs which appear like the compound spinnerets of the Diaspinae. One of these groups is represented at figure 1*c*. The male of this species was found, but in too mutilated condition for detailed description. A shriveled balsam-mounted specimen showed the body, including the style, to be 1 mm. ($\frac{1}{25}$ inch) in length. The length of the style is two-sevenths of the whole length of the body. On each side of the style there is a pair of hairs which resemble those of *Rhizococcus araucariae*. (See Agricultural Report, 1880, Plate X, fig. 1*b*.) The antennæ and wings are normal. The sac of the male is egg-shaped. Only empty ones were observed, each of which had an opening at one end from which the male doubtless emerged (Fig. 1*d*). The sac is about 1.5 mm. (.06 inch) in length. They occur in masses.

CARTERIA MEXICANA, new species (Plate XIX, figs. 1–1*h*)

On looking over the collection of coccids in the Museum of Comparative Zoology, which Dr. Hagen kindly placed at my disposal, I found a twig of mimosa from Tampico, Mex., which bore a number of globular or more or less stellate masses of what proved on further examination to be lac. Each of these masses contained an insect. This insect proves to belong to the same genus as the two lac insects already described, but is specifically distinct from either.

As the specimen which I have is a very small twig, which bore only about fifteen insects, it may not represent well the usual appearance of this lac. On this twig the lumps of lac excreted by the individual insects occur singly or are but slightly massed. Each lump is six-lobed at its base; this is more marked in the case of the immature specimens than with the adults (Plate XIX, fig. 1). This stellate form of the lump of lac is due to a similar form of the body of the insect which excretes it. Figure 1*a* represents an immature female seen from above, which is approximately from the caudal end. The natural attitude of the insect is, like that of the other lac insects, with its cephalic end next to the plant and the caudal end farthest from it. The specimen from which the figure was drawn had been boiled in caustic potash, and thus rendered transparent. The mouth parts and antennæ are represented as showing through the body; the other organs figured are on the caudo-dorsal surface of the body. The anal tubercle and the spine are well developed. The perforated plates, the openings of the lac glands, are also well developed, but are sessile. This is the most obvious difference between this stage and the adult. Closely associated with each perfo-

rated plate is a large spiracle; these being on the sides of the body are shown only in profile.

The form of the body of an adult female is represented at figure 1*d*. In this stage the lac tubes are well developed, as shown in the figure. The extremity of a single lac tube, with its perforated plate, is represented at figure 1*e*. Four spiracles are present, one on each side of the body laterad of the anal tubercle, and a pair near the mouth parts (Fig. 1*d*). One of the caudal spiracles is represented at figure 1*g*. As in the other species of this genus, the opening of the spiracle is surrounded in each case with a number of spinnerets. The anal ring (Fig. 1*h*) consists of four plates, two of which bear three spines each, and two two spines each. Surrounding the anal ring is a pair of chitinous pieces forming a ring. This second ring I have observed in many genera of this family, and I believe the number and shape of the plates of which it is composed will be found to afford generic characters. These two rings are partially surrounded by a fringe of plates and teeth (Fig. 1*f*).

A NEW WAX INSECT

In the old collection of the Department of Agriculture I found several twigs of oak bearing large masses of bright yellow, and nearly spherical, sac-like bodies which appear to be largely composed of wax. Each of the sac-like bodies contained the shriveled remains of an insect which evidently excreted it, and which proves to belong to an undescribed genus of the Coccinae. The twigs of oak belong to two species, native of Arizona, *Quercus oblongifolia* and *Quercus undulata,* variety *Wrightii.* I have also specimens of the same insect from the Museum of Comparative Zoology infesting what is probably *Quercus agrifolia,* and which were collected in California by Osten-Sacken.

Judging from the specimens before me, this insect occurs in sufficiently great numbers to be of economic importance if the excretion can be utilized as is the excretion of an allied insect which produces the true white wax of commerce. The matter is now being investigated by the chemist of the Cornell University Experiment Station, and will probably be discussed in the next report of that institution.

I submit the following characterization of the genus to which this insect belongs:

Genus **CEROCOCCUS**, new genus

Adult female apodous; body covered with a layer of waxy excretion, which forms a continuous sheet, not composed of a number of plates more or less closely united, as in Ceroplastes. The excretion forms a complete sac about the body of the insect. At the caudal end of this sac there is an opening; and on the dorsal part near the center the larval skin is imbedded but plainly visible. The adult female is provided with spinnerets of two kinds, which may be designated as double pores and simple pores, respectively. Anal segment with the two caudal lobes characteristic of the Coccinae; anal ring with eight spines; anal plate of a single piece, and situated dorso-caudad of anal ring. Mentum of two segments.

CEROCOCCUS QUERCUS, new species (Plate XX, figs. 2–2*e*)

Sac of female.—The sac in which the body is inclosed is bright yellow in color, elliptical in outline, very convex above. The lateral margin bears a row of tubercles which evidently correspond to the segments of

the body. Length 6 mm. (.24 inch), width 5 mm. (.2 inch). Usually these sacs are more or less massed around the twig (Plate XX, fig. 2).

The form of the sac of the immature female is represented by figure 2*b*. The larval skin occupies the center of the dorsal surface, and the excretion forms a thick ring around this skin.

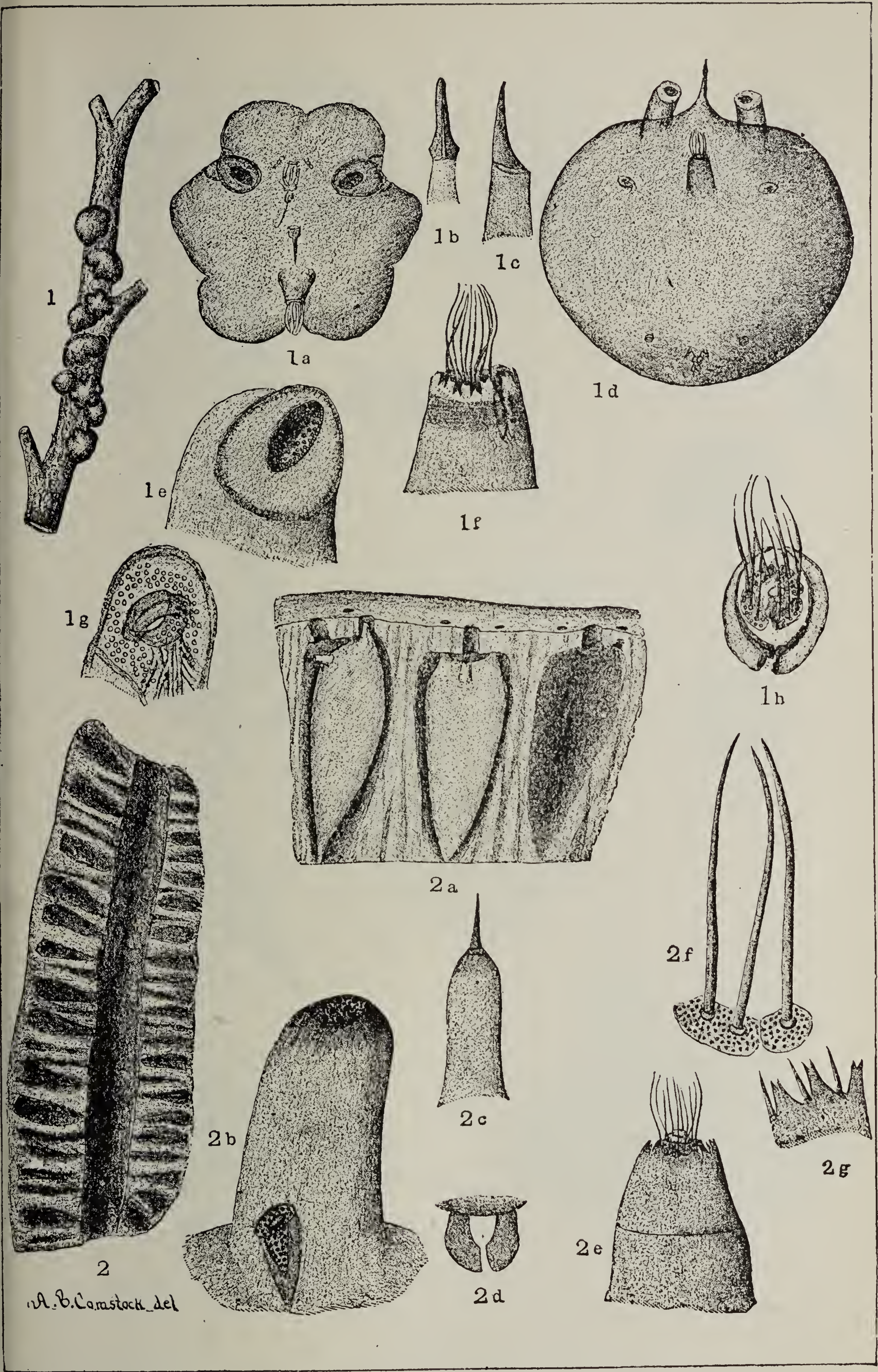
Female.— The body of the female is elliptical in outline, with neither legs nor antennæ. The caudal end of the body is terminated by two prominent lobes (Fig. 2*e*), each of which bears a long terminal bristle and several shorter ones. The anal ring is situated in a deep depression, from which the spines of the ring hardly project. This is represented in optical section in figure 2*e*. Dorso-caudad of the anal ring, near the opening of the depression in which this ring is situated, is the anal plate. The edge of it is represented as a line extending from the base of one lobe to the other in figure 2*e*. Scattered over the surface of the body are a large number of paired pores. These are represented in figures 2*e* and 2*c*. A few single pores occur also. Near the caudal end of the body there are several round bodies, which I have termed the madreporiform bodies (Fig. 2*c*).

Sac of male.— The sac of the male is oval, with an opening at one end from which the male emerged (Fig. 2*d*). The male was not observed.

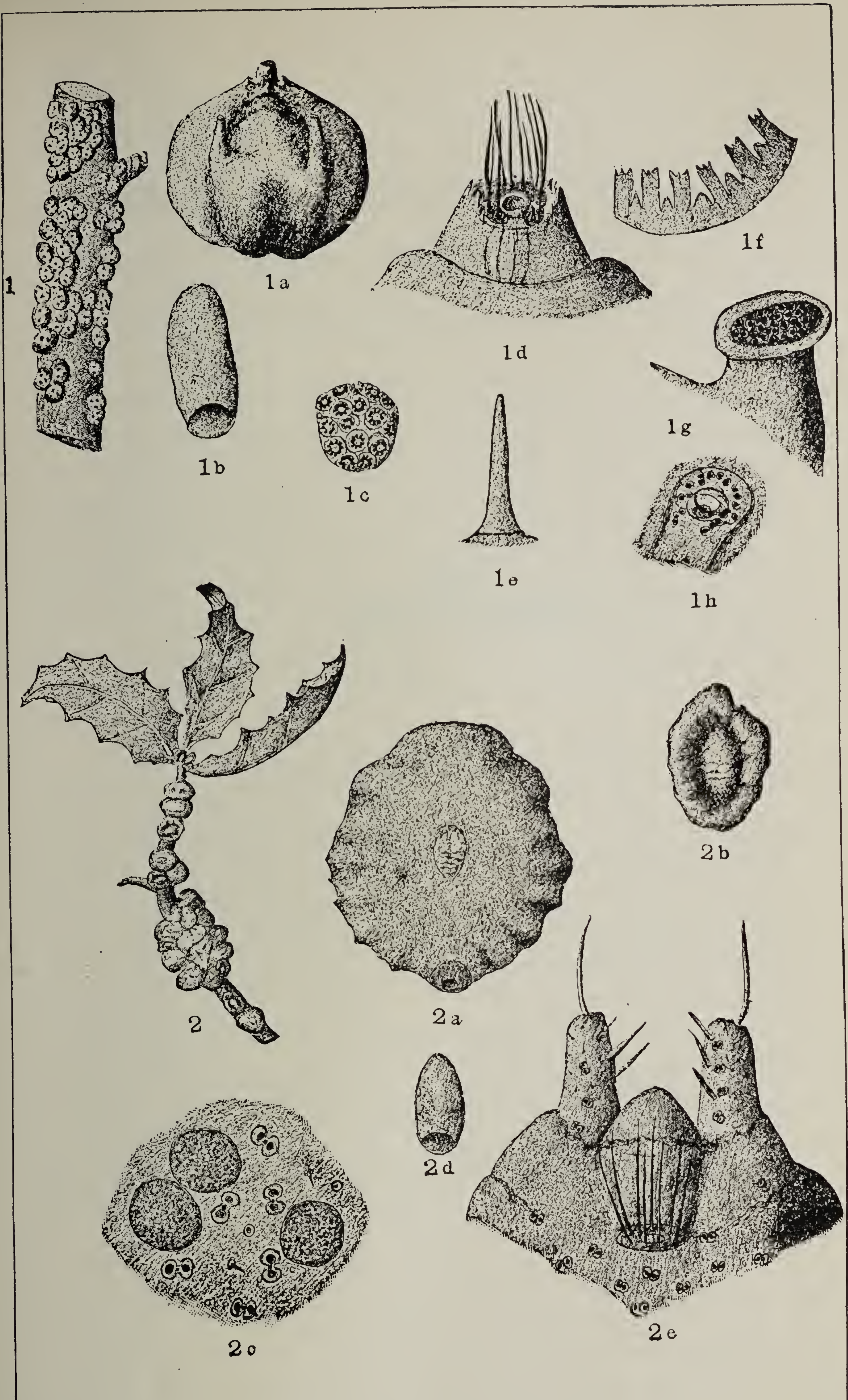
NOTE ON THE STRUCTURE OF MEALY BUGS

In Dactylopius, and presumably in other genera of the Coccinae, the opening of the oviduct is distinct from that of the posterior end of the alimentary canal, being on the ventral side between the sixth and seventh abdominal segments. I have watched a female during the act of ovipositing, so there is no doubt respecting this matter. Consequently the expression *ano-genital ring,* which has been applied by authors to the ring of hairs and spinnerets at the caudal end of the body, is not correct. The term *anal ring* is the appropriate one.

We have also observed in Dactylopius a pair of openings on the dorsal side of the sixth abdominal segment, which are evidently homologous with the honey tubes of the Aphididae. A female mealy bug was gently rubbed near the caudal end of the body, when suddenly there appeared two drops of a clear fluid, resembling in appearance the honey-dew of plant lice. This experiment was repeated many times and with many specimens. Mr. Pergande assures me that he has observed a similar excretion from a pair of openings on the cephalic margin of the first thoracic segment also.



(Plate XXXI, Cornell series)



(Plate XXXII, Cornell series)

REPORT OF THE DEPARTMENT OF ENTOMOLOGY

Professor J. Henry Comstock

(From the Second Report of the Cornell University Experiment Station, 1883)

The work of the Entomological Department of this Station, during the past year, has been a continuation of certain investigations begun by the writer while Entomologist to the United States Department of Agriculture. Pecuniary aid in carrying on these investigations was received from that Department; and a report embodying the results was submitted to the Commissioner of Agriculture. Owing to the limits of the space which could be given to Entomology in the Annual Report of the U. S. Department of Agriculture, only a part of the writer's report was published in that place; the remainder of it is now offered to the public.*

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* The following is a list of the topics discussed by the writer in that part of his report which is published in the Annual Report of the U. S. Department of Agriculture for 1881:

The Apple Maggot (*Trypeta pomonella* Walsh). A white cylindrical maggot which eats into the pulp of apples causing them to decay, and which when fully grown goes into the ground to transform. The adult is a black and white fly with banded wings.

The Vine-loving Pomace Fly (*Drosophila ampelophila* Loew). A small white maggot, found abundantly in decaying apples, and producing a small, clear-winged, red-eyed fly. This insect is found about cider mills and wine cellars, where it becomes a nuisance. It is said also to infest grapes while hanging on the vines.

The Pretty Pomace Fly (*Drosophila amoena* Loew). A small white maggot, resembling the larva of the Vine-loving Pomace Fly, and, like that species, found in decaying apples; but unlike that species going into the ground to transform, and developing into a red-eyed fly with black spots on its wings.

The Ocellate Leaf Gall of Red Maple (*Sciara ocellaris* O. S.). Circular ocellate spots, on the leaves of the red maple (*Acer rubrum*) about three-eighths inch in diameter, with disk yellow, and margin and central dot, during one stage of their growth cherry red.

In submitting this report I wish to acknowledge the assistance in the preparation of material for it, of Mr. Henry Ward Turner and Mrs. Anna B. Comstock. The illustrations have all been drawn from nature by Mrs. Comstock.

A part of the work required in my laboratory of each student in the Course in Agriculture is the making of original investigations respecting the life history of one or more insects injurious to agriculture. I submit, as a supplement to my report, the results of one of these investigations, a study of the Tineidae infesting apple trees at Ithaca, by Mr. A. E. Brunn, of the class of 1882.

SECOND REPORT ON SCALE INSECTS

Including a monograph of the subfamily Diaspinae of the family Coccidae, and a list, with notes, of the other species of scale insects found in North America

INTRODUCTION

Owing to the large number of species of scale insects which have been described, and to the fact that the greater part of the descriptions have been published in journals of limited circulation, it is now impossible, for one who does not make a special study of this family of insects, to determine with certainty the various species belonging to it. I have, therefore, thought best in

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LADYBIRDS (Coccinellidae). Descriptions of the different stages of several species of ladybirds found preying upon insects injurious to vegetation.

METHODS OF DESTROYING SCALE INSECTS. Results of experiments made in California, chiefly with lye.

LAC INSECTS. Descriptions of all the known species of lac insects, three in number. Of these, two are American and are here described for the first time. Lac insects are the insects which produce lac, the substance from which shellac and the lac dyes are made.

A NEW WAX INSECT (*Cerococcus quercus*, new species). A coccid found in Arizona and California which excretes a large amount of wax.

NOTE ON THE STRUCTURE OF MEALY BUGS. On the position of the opening of the oviduct; and on the presence of organs homologous with the honey tubes of the Aphididae.

presenting descriptions of certain new species of the subfamily Diaspinae to give the characters by which the other known American species may be recognized, and thus to place in the hands of the American reader a work which shall represent the present state of our knowledge of this very important group of insects.

In order that the species can be determined with the least possible difficulty, I have carefully prepared analytical tables, and have given figures which represent the distinctive characters of each species.*

As scale insects are permanently attached to the plants which they infest, they are much more liable to be transported from one country to another than are any other insects. For this reason, a work which represents merely the species of a single fauna is very imperfect. The extensive importation of plants and of cuttings renders our plants liable to become infested with scale insects from all parts of the world. I have therefore given the names, and as far as possible the distinctive characters, of the species of the Diaspinae which have been described in other countries. It has been impracticable, however, to introduce such species into the analytical tables without specimens for examination.

CHARACTERS OF THE DIASPINAE

Owing to the great diversity of form and structure among the species belonging to the family Coccidae, or scale insects, this family has been divided into several sections, or subfamilies. This paper is devoted to one of these subfamilies, the Diaspinae.

* It has not seemed worth while to reproduce the figures and descriptions given in my first report on scale insects (Annual Report Department of Agriculture, 1880), as that paper will be accessible to all who care to use this monograph, and may therefore be considered a part of it.

I regret that, owing to my absence from Washington during the printing of that report, there are in the body of it many important typographical errors. These are principally in the references to plates. The explanation of plates on pages 372, 373, is correct; and in this report wherever a reference is made to a species figured in that one, the reference to the plates of that report is corrected if necessary.

This subfamily includes the greater number of the very important pests belonging to the family of scale insects. Familiar examples are the oyster-shell bark louse of the apple, the two red scales of the orange, and the white scale of the oleander. (For the characters of the other subfamilies, as well as for those of the family Coccidae, see my first report on scale insects, pages 277–279.)

The Diaspinae includes those species of scale insects which form a scale composed in part of molted skins and partly of an excretion of the insect. This apparently trivial character is correlated with important structural characters which mark a well-defined group.* The most important of the structural characters is the peculiar form of the last segment of the body. This segment is highly specialized for the excretion and manipulation of wax. It is furnished with many openings and appendages, both of which vary greatly in number and form. None of the species, however, present the peculiar anal plates characteristic of the Lecaninae; nor is the caudal extremity divided into two lobes of the form characteristic of the Coccinae. In the Diaspinae the caudal end of the body is usually terminated by a pair of lobes; but these lobes are of an entirely different structure from the lobes of the Coccinae. (Compare the figures on Plate I of this report with figure 2*e* of Plate XX, Agr. Report for 1881.)

The peculiar characters of the last segment of the body in the Diaspinae are not presented by the larvae till after the first molt, nor by the male after the change to pupa.

EXPLANATION OF TERMS

The members of the subfamily Diaspinae differ so greatly from the ordinary forms of insects that in classifying and describing them it becomes necessary to use characters peculiar to them. These characters are discussed in the Report of the U. S. Department of Agriculture for 1880, pages 281–283, and are figured on

* In the genus Cerococcus which belongs to the Coccinae, the larval skin forms a part of the covering of the insect. A glance, however, at the last segment of the body of one of these insects is sufficient to show that the genus does not belong to the Diaspinae.

Plates I and II of this report. The following are the terms employed in referring to these characters:

I. Scales

Scale.— The term scale is applied to the thin pellicle which covers the dorsal surface of the bodies of all the Diaspinae. It is composed in part of molted skins and partly of an excretion of the insect. (For figures of different forms of scales see Plate II.)

Ventral scale.— In certain species there is a pellicle between the body of the insect and the bark of the plant to which the insect is attached. This I have termed the ventral scale. It varies in thickness from an almost imperceptible film to a scale as thick as the scale proper, or dorsal scale. In certain species of Aspidiotus I have found that it is composed in part of the ventral half of the molted skins; the larval skin splits along the lateral margin of the body, and one-half of it goes to strengthen the dorsal scale and one-half the ventral scale, as with the dorsal scale to these molted skins is added an excretion of the insect.*

Exuviae.— This term is applied to the molted larval skins which form a part of the scale. The size and position of the exuviae are important generic characters (see Plate II). The number of skins in a scale is a sexual character. In the scale of the female (Plate II, figs. 1, 2, 3, etc.), there are two molted skins; in that of the male (Plate II, figs. 1*a*, 2*a*, 3*a*, etc.), there is but one.

II. Last segment of female

Vaginal opening.— Near the center of the ventral surface of this segment there is a large transverse opening; this is the vaginal opening. (See Plate I, *a*, *a*.)

Anus.— The anus is on the dorsal surface of the body; but it is usually visible from the ventral surface, appearing as a transparent circular spot. (Plate I, *b*, *b*.) Its position varies in different

* The only notice that has been made of the ventral scale by previous writers is the establishment of the genus Targionia, by Signoret, for a species in which this scale is greatly developed. This character is, however, evidently not of generic importance. I have before me a series of species of Aspidiotus which shows a gradation from a species in which the ventral scale is imperceptible to one in which it is as thick as in the *Targionia nigra* of Signoret.

species from near the caudal end of the body (Plate I, fig. 1*b*) to a point opposite the penultimate ventral segment (Plate I, fig. 2*b*).

Spinnerets.— There are many openings and tubular appendages of this segment which serve for the emission of the excretion of which the scale is composed; these may be termed spinnerets. In most species there is a greater or less number of peculiar spinnerets arranged in groups around the vaginal orifice (Plate I, *c, d, e*). These spinnerets differ remarkably from others in being compound, each one being a circular plate perforated by several small openings. It is to these compound spinnerets that reference is made in the descriptions by the expression *groups of spinnerets.* In most species the number of the groups of these spinnerets is either four or five. When they are five, one is situated cephalad of the vaginal opening, and two each side of it. These are designated as the *mesal group,* the *cephalo-laterals,* and the *caudo-laterals* respectively.*

Lobes.— These are the most conspicuous of the appendages of this segment. They are represented at f^1, f^2, and f^3 on Plate I. The number of these lobes varies from one pair to six pairs. These pairs of lobes are designated as the first, second, third, etc., beginning with the mesal lobes.

Thickened lateral margin.— In some species a part of the lateral margin of this segment is thickened, appearing to be of the same structure as the lobes (Plate I, fig. 3*g*).

Thickenings of body wall.— In certain species thickenings of the body wall occur near the bases of the lobes but more or less distinct from them. The number, size, and position of these thickenings afford good specific characters. (See Plate I, fig. 3*h*.)

Incisions.— In certain species the caudal margin of the segment is incised two or three times on each side of the meson. These incisions and the edges of them, which are usually thickened, afford characters of importance. (See Plate I, fig. 1*i*, incisions; fig. 1*j*, thickened margins of incisions.)

* In the Report for 1880 these groups were designated as the anterior, anterior laterals, and posterior laterals, respectively.

Spines.— There are several spines situated near the posterior margin of the segment. There are usually two of these associated with each lobe, one on the dorsal surface and one on the ventral. Others are situated at various intervals between the lobes and the penultimate segment. In many instances these spines appear to be tubular; and I have repeatedly seen threads extending from them; hence they are doubtless spinnerets. They may be distinguished from other setiform appendages by their globular base. (See Plate I, *k, k*. The spines are not represented in figure 2 of this plate to avoid complicating the figure.)

Plates.— Under this name I have classed all the remaining appendages which fringe this segment. They are usually long, flattened, and more or less notched or toothed. Sometimes, however, they are hair-like or spine-like; but they never have the globular base characteristic of the true spines. Previous writers have not distinguished between the spines and plates; hence the plates are sometimes described as spines. (For figures of plates see Plate I, *l*.)

Wax ducts.— It often happens, especially in the case of specimens which have been prepared with caustic potash, that the last segment of the body appears to bear on its surface several long hairs with club-shaped bases. Very careful focusing will show that the club-shaped parts of these organs are openings in the body wall, and what appears to be hairs are really organs within the body. These are represented in Plate I, fig. 2*m*. I have not definitely ascertained the function of these organs, but believe them to be wax ducts. They have been described as external appendages of the segment under the name of tubular spinnerets, and are figured by Signoret in several instances as such. A second form of wax ducts which are often mistaken for tubular spinnerets is represented at m^1.

Elongated pores.— In certain species there are peculiar openings each situated in a prolongation of the margin of the body. These are slit-like in form and are described as elongated pores. (See figure 2*n* of the plate, where some are represented with wax ducts leading to them.)

III. Terms denoting position or direction of parts

For indicating the position and direction of parts the well-known adjectives *dorsal, ventral, lateral, cephalic, caudal, proximal,* and *distal* are used in preference to less definite terms; as are also the corresponding but less familiar adverbial forms, *dorsad, ventrad,* and so forth. When the position or direction of a part is referred to the middle line of the body (the *meson*), the adjective *mesal* or the adverb *mesad* is used.*

METHODS OF STUDY OF SCALE INSECTS

The scales of the scale insects are among the easiest of all entomological specimens to be preserved. As a rule all that is necessary is to dry the leaf, twig, or bit of bark upon which the insects are. It may then be pinned into a cabinet and the scales preserved indefinitely without further preparation.

The adult females of Diaspinae are also easily preserved in the same way in sufficiently good state for specific identification. Although the body in drying shrivels greatly, the last segment, which presents the important characters, will retain its form indefinitely. It is better, however, to remove the insect while it is fresh from under the scale and to mount it in glycerin or Canada balsam for microscopic study. In many cases tolerably good work can be done with specimens simply mounted without previous preparation. But very much better results can be obtained by first boiling the insect in a solution of caustic potash, and then mounting in glycerin. In fact it is often impossible to observe the groups of spinnerets until after the insect has been prepared in this manner. The necessity of this treatment is probably due to the large amount of excretion with which the openings and appendages of this segment are covered. It is very difficult to preserve the males in good condition. I have had the best results with glycerin.

* For a full discussion of the Anatomical Nomenclature as applied to Entomology, see the writer's *Guide to Practical Work in Elementary Entomology*. Published at Cornell University, Ithaca, New York.

OTHER TOPICS

For a discussion of the following-named topics see Report of the U. S. Department of Agriculture for 1880:

Metamorphoses of the Diaspinae, pp. 279–283.

Methods of preventing the spread of scale insects, pp. 284–285.

Methods of destroying scale insects, pp. 285–290.

Useful products of the Coccidae, p. 291.

CLASSIFICATION OF THE SUBFAMILY DIASPINAE

The genera of the true scale insects, or Diaspinae, which are represented in North America, may be determined by the following table:

A. Scale of female circular, with the exuviae either central or more or less nearly marginal.

  B. Scale of male but little elongated, with the exuviae more or less central; scale usually resembling that of the female in color and texture (Plate II, figs. 1*a* and 2*a*). **Aspidiotus.**

  BB. Scale of male elongated, with the exuviae at one extremity.

    C. Scale of male white and carinated (Plate II, fig. 3*a*). **Diaspis.**

    CC. Scale of male not white and with no central carina (Plate II, fig. 6*a*). **Parlatoria.**

AA. Scale of female elongated, with the exuviae at one extremity.

  D. Exuviae small.

    E. Scale of male white and carinated* (Plate II, fig. 4*a*); last segment of female with five groups of spinnerets. **Chionaspis.**

    EE. Scale of male white, but not carinated; female with eight groups of spinnerets (Fig. 15). **Poliaspis.**

    EEE. Scale of male similar in form to that of the female (Plate II, fig. 5*a*). **Mytilaspis.**

  DD. Exuviae large.

    F. Two molted skins visible on the scale of the female (Plate II, figs. 7 and 8). **Parlatoria.**

    FF. Second skin covered by a secretion (Plate I, fig. 9). **Uhleria.**

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* In *Chionaspis ortholobis* Comstock the scale of the male is not carinated. This species infests willow in California.

Genus **ASPIDIOTUS** Bouché

Bouché, Naturgeschichte der Garten Ins. 1833, p. 52

This genus includes species of Diaspinae in which the scale of the female is circular or nearly so, with the exuviae at or near the center; and the scale of the male somewhat elongated, with the larval skin at one side of the center, or near one extremity.

The last segment of the female usually presents four groups of spinnerets; in some species there are five groups; in a few there are none; and in one, now placed in this genus provisionally, there are six groups.

Two types of the scale of the female exist. In one, the exuviae are covered by excretion, and their position is indicated by a nipple-like prominence which is often marked with a central white dot and a concentric ring of the same color (Plate II, fig. 1). I have observed this character in no other genus. In the second type the exuviae are naked (Plate II, fig. 2). The species in which the scale of the female is of this kind can be distinguished from Diaspis only by the scale of the male, which is carinated in that genus.

The species of Aspidiotus which have been observed in this country may be distinguished by the following table:

ASPIDIOTUS

A. Last segment of female with six groups of spinnerets. **sabalis.**

AA. Last segment of female with less than six groups of spinnerets.

B. Last segment of female with three pairs of well-developed lobes; and with elongated thickenings of the body wall terminating at or near the bases of the lobes. (See Plate I, fig. 3*h*.)

C. Last segment of female with five groups of spinnerets. **obscurus.**

CC. Last segment of female with four groups of spinnerets.

D. Female with three large compound plates laterad of third lobe. **ficus.**

DD. Female with two small plates laterad of third lobe. **perseae.**

CCC. Last segment of female with no groups of spinnerets.

E. Female with large projection on the cephalic end of body. **personatus.**

EE. Female with cephalic end normal.

F. Female with large plates. **aurantii.**

FF. Female with small plates.

G. Anus not cephalad of club-shaped thickenings between second and third lobes. **tenebricosus.**

GG. Anus cephalad of club-shaped thickenings.

H. Eight club-shaped thickenings laterad of each mesal lobe. **mimosae.**

HH. Only two club-shaped thickenings laterad of each mesal lobe. **similacis.**

BB. Second and third pairs of lobes wanting, or much smaller than the mesal pair; caudal margin of segment with two pairs of incisions, *with thickened edges.* (See Plate I, fig. 1*i*.)

I. Groups of spinnerets wanting.

J. Scale of female very convex. **rapax.**

JJ. Scale of female flat. **perniciosus**

II. Groups of spinnerets present.

K. Scale of female very convex, only four groups of spinnerets.

L. Only two pairs of incisions, plates prominent. **cydoniae.**

LL. A slight incision laterad of each second incision, plates less prominent. **convexus.**

KK. Scale of female flat, species with sometimes a fifth group of spinnerets.

M. With two or three pairs of lobes. **juglans-regiae.**

MM. Second and third pairs of lobes obsolete or wanting.

N. Mesal lobes parallel, and each conspicuously narrowed on each side. **uvae.**

NN. Mesal lobes converging distad, each narrowed but little, if any, on mesal margin. **ancylus.**

BBB. With neither elongated thickenings of the body wall, nor incisions *with thickened edges.*

O. Groups of spinnerets wanting. **abietis.**

OO. Only two groups of spinnerets. **pini.**

OOO. With four groups of spinnerets.

P. Second and third lobes deeply incised, plates simple. **parlatorioides.**

PP. Second and third lobes simple, plates notched and toothed.

Q. Scale of female with larval skin naked. **nerii.**

QQ. Scale of female with exuviae covered.

R. Plates exceeding spines in length. **cyanophyli.**

RR. Dorsal spines of the second and third lobes much longer than the plates. **spinosus.**

THE HEMLOCK SCALE

1. Aspidiotus abietis n. sp. (Fig. 1).

At Ithaca, N. Y., there is a species of Aspidiotus quite common on the lower surface of the leaves of hemlock (*Abies Canadensis*), for which, it being undescribed, I propose the name *abietis.*

Scale of female.— The scale of the female very closely resembles that of *Aspidiotus pini* except that it is usually more nearly circular; this is probably due to the difference in the shape of the leaves which the two species infest. The color of the scale is dark gray, often approaching black, with the margin lighter, and sometimes with a bluish, brownish, or purplish tinge. As with *A. pini,* in many specimens of the fully formed scale the part covering the exuviae is more or less distinct, appearing like a small scale with a light margin superimposed upon a larger scale. Length of scale, 1.3 to 2 mm. (.05 to .08 inch); width about nine-tenths of the length.

Female.— The last segment of the female presents the following characters:

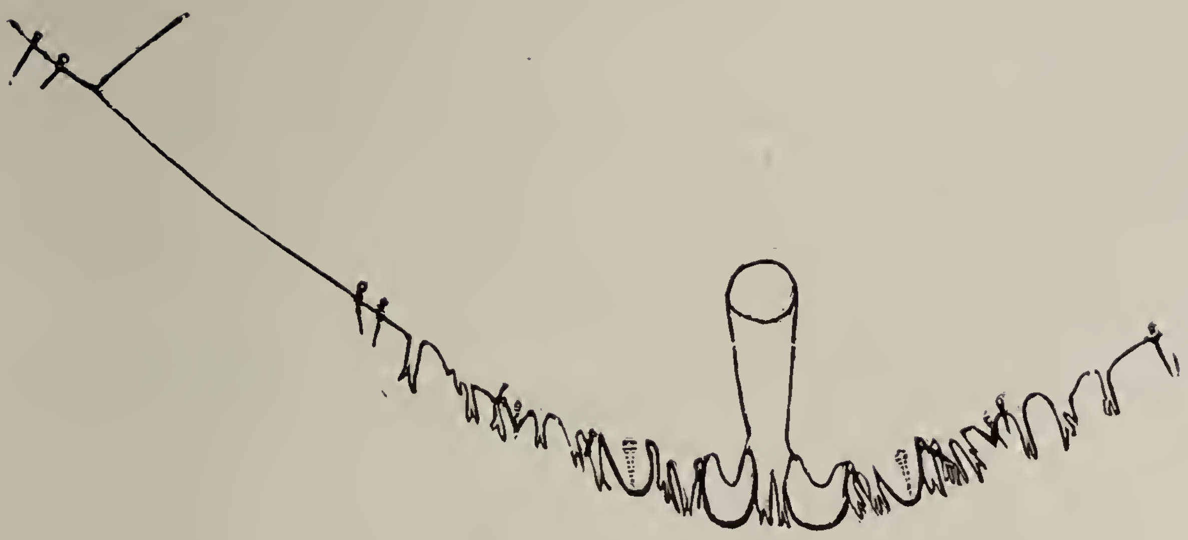


FIG. 1 (Fig. 93. Cornell series)

The *groups of spinnerets* are wanting.

The mesal and second *lobes* are well developed; their distal extremities are rounded; the third lobe of each side is small and acutely pointed.

The *plates* are rather short and irregularly fringed; there are two between the mesal lobes; two between each mesal and second lobe; three between each second and third lobe; and usually three laterad of each third lobe.

The *spines* of the dorsal surface are as follows: one laterad of each mesal lobe; one upon each second and third lobe; and one laterad of the most lateral plate. Each ventral spine with the exception of the first, which is wanting, is situated laterad of the corresponding dorsal spine.

Scale of male.— The scale of the male is as wide as that of the female and a little longer. It resembles that of the female in color.

Male.— The male is of bright orange color with the thoracic band very dark brown, nearly black.

Described from many specimens of each sex.

PUTNAM'S SCALE

2. Aspidiotus ancylus Putnam.

Diaspis ancylus Putnam. Trans. Iowa State Hort. Soc. 1877, p. 321.
Aspidiotus ancylus Putnam. Proc. Davenport Academy, Vol. ii, p. 346.

This species infests many plants. We have found it upon ash,

beech, bladder nut, hackberry, linden, maple, oak, osage orange, peach, and water locust. It was first described from specimens found in Iowa. We have also observed it in New York and in the District of Columbia.

For description and figures of this insect, see Agr. Report 1880, page 292.

From this species I have bred the hymenopterous parasite *Cocophagus varicornis* Howard, described in Agr. Report 1880, page 360.

THE RED SCALE OF CALIFORNIA

3. Aspidiotus aurantii Maskell.

Aspidiotus aurantii Maskell. Trans. and Proc. New Zealand Institute, vol. xi, p. 199.

Aspidiotus citri Comstock. Canadian Entomologist, vol. xiii, p. 8.

This species is the most important insect infesting orange and lemon trees in California. It has been introduced into that State from Australia.

For descriptions and figures of the different stages of this insect, see Agr. Report 1880, pages 293–295. Make following corrections in that report: page 293, line 29, for Plate XIV read Plate XIII; page 294, line 34, for Plate XIII read Plate III.

THE CONVEX SCALE

4. Aspidiotus convexus Comstock.

This species infests willows and poplar in California. For description and figure, see Agr. Report 1880, page 295.

THE CYANOPHYLLUM SCALE

5. Aspidiotus cyanophylli Signoret (Fig. 2).

Aspidiotus cyanophylli Signoret. Essai. 1869, 119.

Upon certain species of fig (*Ficus indica* and *Ficus laurifolia*), in conservatories at Washington and at Cambridge, Mass., I have found a species of Aspidiotus which I believe to be the same as

that described by Signoret as infesting *Cyanophyllum magnificum* at Paris.

Scale of female.— The scale of the female is circular, and brownish yellow, with the exuviae central, and bright yellow. The exuviae are, however, normally covered with a nipple-like mass of white excretion.

Female.— The body of the female is lemon-yellow, with the last segment brownish.

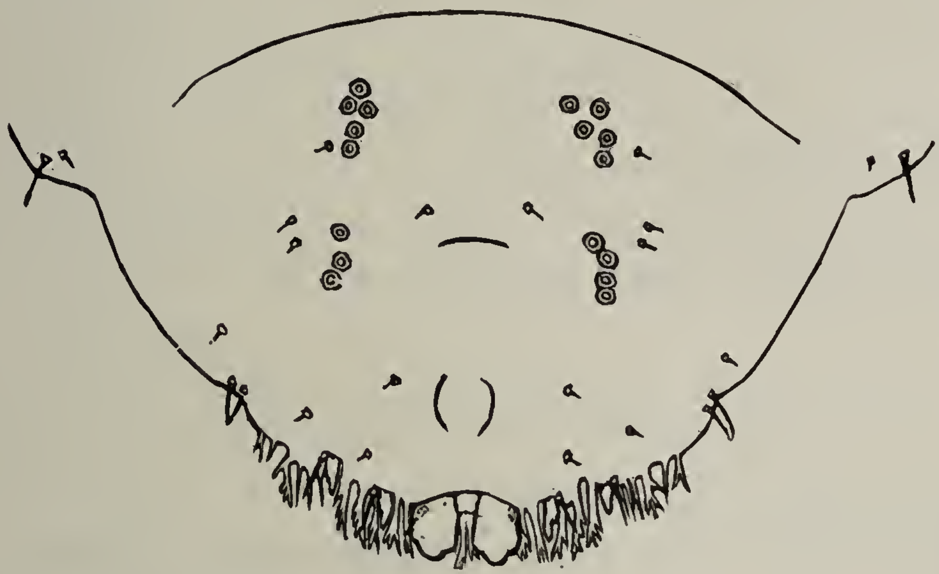


FIG. 2 (Fig. 94, Cornell series)

There are four *groups of spinnerets*; the cephalo-laterals consist each of four or five; the caudo-laterals of three to five.

The mesal *lobes* are large; each is suddenly narrowed on both sides near the distal end; the second lobe of each side is long and slender, appearing much like a plate; the third lobe is similar in shape but smaller.

The *plates* are very long and usually deeply incised; in each case they extend beyond the lobes. There are two between the mesal lobes, with the distal ends incised; two similar ones between each mesal and second lobe, of these the mesal plate is the more delicate; three between each second and third lobe, these are deeply incised on their lateral margins. Laterad of the third lobe there are usually five or more plates, some of which are simple and some branched.

The *spines* are very long and slender; they do not, however, exceed the plates in length. The spines of the dorsal surface are

as follows: one on the lateral part of the base of each mesal lobe: one on each second lobe; one laterad of each third lobe; and one at about one-third the distance from the third lobe to the penultimate segment. Each ventral spine excepting the first pair, which are wanting, is situated laterad of the corresponding dorsal spine. Other small spines scattered over the surface of the segment and visible in specimens prepared with caustic potash are represented in the figure.

THE QUINCE SCALE

6. Aspidiotus cydoniae Comstock.

This species I found upon quince in Florida. It is described with figure in Agr. Report 1880, page 295.

THE RED SCALE OF FLORIDA

7. Aspidiotus ficus (Riley MSS).

Chrysomphalus ficus Riley MSS., Ashmead, American Entomologist, 1880, p. 267.
Aspidiotus ficus Comstock, Canadian Entomologist, Vol. XIII, p. 8.

The specific name *ficus* was proposed for this species by Professor Riley because he had found the insect quite injurious to *Ficus nitida*. The species has, however, attracted much more attention as an enemy of the orange. As yet I have only seen specimens from Florida and Cuba. In the Agr. Report for 1880, pages 296–300, I have given descriptions of both sexes and all stages of this insect. In the same report, Plate III, figures 2, 2*a*–2*f*, represent the scales and young; Plate XXI, figure 3, male; Plate XII, figure 2, last segment of female; and Plate XIII, figure 2, margin of last segment of female.

THE ENGLISH WALNUT SCALE

8. Aspidiotus juglans-regiae Comstock.

This species was described from specimens found upon English walnut in California. I afterwards found specimens upon locust,

pear, and cherry in New York and District of Columbia. See Agr. Report 1880, page 300, for description and figure.

THE MIMOSA SCALE

9. **Aspidiotus mimosae** n. sp. (Fig. 3).

Upon a twig of mimosa from Tampico, Mexico, the same twig that bore the lac insects (*Carteria mexicana*), described by me elsewhere, I found an undescribed species of Aspidiotus.

Scale of female.— The scale of this species very closely resembles that of *A. tenebricosus.* It is very dark gray, agreeing in color with the bark to which it is attached. It is quite convex with the exuviae central. The protuberance indicating the position of the exuviae is marked with a white dot and concentric ring.

Female (Fig. 3).— The last segment of the female presents no *groups of spinnerets.*

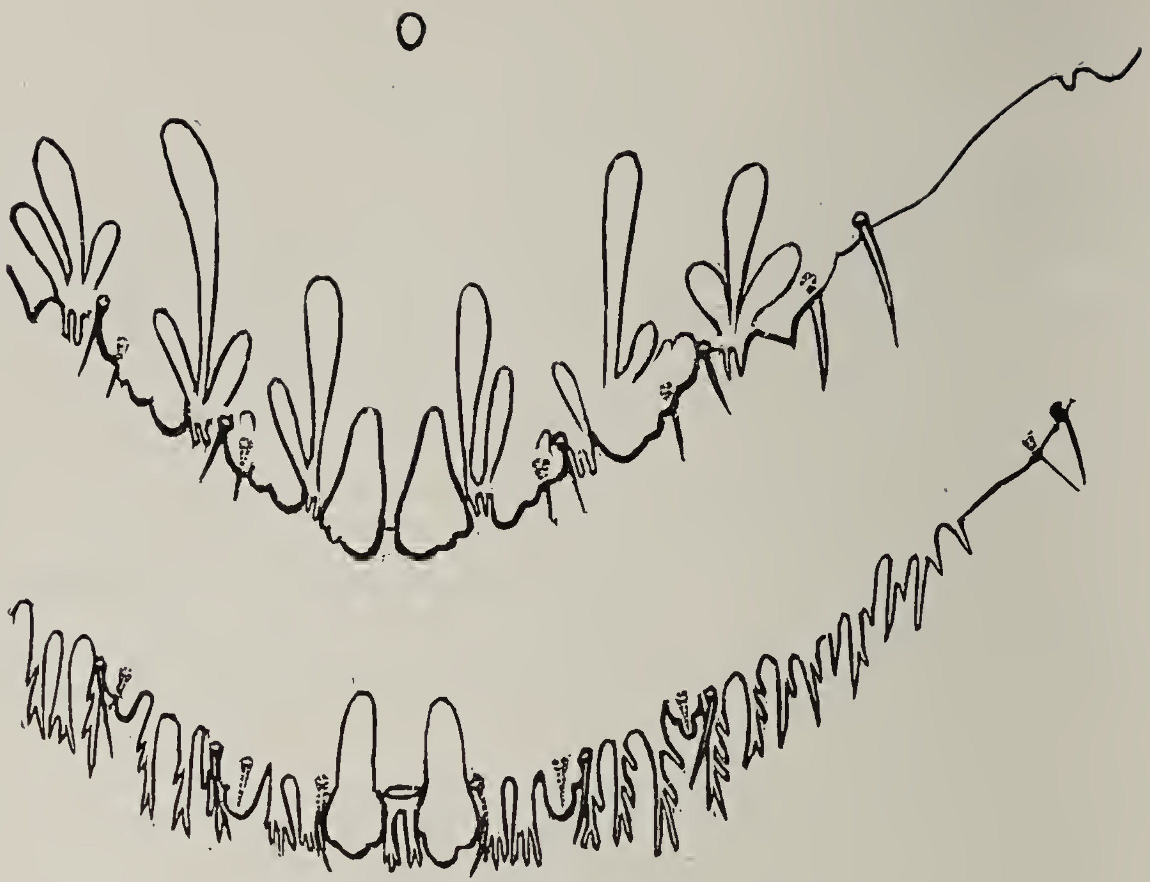
There are three pairs of well-developed *lobes*; the mesal lobes are rounded caudad, but usually with two notches on the lateral margin, and taper to a point cephalad; each second lobe bears two and sometimes three notches on its caudo-lateral margin; the third lobe is larger than the second and bears three notches. A short distance laterad of the third lobe the margin of the segment is prolonged into a triangular fourth lobe.

The *plates* are very inconspicuous, being invisible in many specimens. They are short and simple; there are two between the mesal lobes; and two laterad of each of the mesal, second, and third lobes.

There is a *spine* on the dorsal surface of each of the second, third, and fourth lobes, and one on each lateral margin near the penultimate segment. On the ventral surface there is a spine a short distance laterad of each of the dorsal spines.

There are two club-shaped *thickenings* between each first and second lobes, of which the mesal is the longer; three between the second and third lobes, of these the intermediate one is the longest, and in some specimens the mesal one is wanting; and three between the third and fourth lobes.

Described from fifteen females.



FIGS. 3 AND 4 (Figs. 95 and 96, Cornell series)

THE OLEANDER SCALE

10. Aspidiotus nerii Bouché (Fig. 4).

Aspidiotus nerii Bouché, Schädl. Gard. Inst. (1833), 52.
Diaspis bouchéi Targioni-Tozzetti (1867), Stud. sul. Coccin.

This species infests a great variety of plants, and is to be found throughout our country from the Great Lakes to the Gulf of Mexico and from the Atlantic to the Pacific. I have studied it upon the following-named plants: acacia, cherry, currant, "China tree," English ivy, grass and clover growing in pots with orange trees upon which I was rearing this insect, lemons from the Mediterranean, lemons from California, maple, Melia, oleander, plum, and yucca. I am indebted to Dr. E. L. Mark and Mons. V. Signoret for European specimens of this species for comparison with American specimens. The male, female, and scale of each sex are described and figured in Agr. Report 1880, pages 301–303; and in this report figure 4 represents the margin of last segment of female.

(63)

THE OBSCURE SCALE

11. Aspidiotus obscurus Comstock.

This is an inconspicuous species which occurs on the bark of the limbs of willow oak at Washington, D. C. For description and figures, see Agr. Report 1880, page 303.

THE PARLATORIA-LIKE SCALE

12. Aspidiotus (?) parlatorioides n. sp. (Fig. 5).

Upon a leaf of bay tree (*Persea carolinensis*) received from Dr. Turner, of Ft. George, Florida, I find a scale, the generic position of which is very uncertain. I place the species in this genus only provisionally.

Scale of female.— The scale of the female (Plate II, fig. 10) is circular with the exuviae marginal. The exuviae are very large, extending from one margin to the center of the scale. This gives the scale the appearance of a circular Parlatoria, like *P. pergandii*; hence the specific name. The color of the scale is light yellow; the exuviae are of a similar color with a brownish tinge. Diameter of scale, about 1.4 mm. (.055 inch).

FIG. 5 (Fig. 97, Cornell series)

Female.— There are four *groups of spinnerets*; the cephalo-laterals consist of nine to fifteen, usually nine; the caudo-laterals of seven to ten, usually nine.

The mesal *lobes* are wide, their sides are parallel, and each is abruptly narrowed on each side near the distal end. The second and third lobes are deeply incised; when these lobes are well-developed each lobelet usually bears a slight notch on its lateral margin. The third pair of lobes is often obsolete.

The *plates* are simple, and taper to a point. There are two between the mesal lobes; one laterad of each of the second and third lobes. On the margin of the segment between the third lobe of each side and the penultimate segment are two pairs of short projections; these may be rudimentary plates.

The *spines* of the dorsal surface are as follows: one at the base of the mesal side of each of the mesal lobes; these spines are long, extending beyond the plates; one between the lobelets of each of the second and third lobes; and one near each pair of the rudimentary plates. The ventral spines are very delicate; there is one laterad of each of the second and third lobes, and one laterad of each of the pairs of rudimentary plates.

The male is unknown. The form of the scale of the male will doubtless determine definitely the generic position of the species.

THE PERNICIOUS SCALE

13. Aspidiotus perniciosus Comstock.

This species I believe to be the most injurious scale insect found in our country. As yet I have found it only in California; and in that State it is most abundant in the Santa Clara Valley. It infests nearly all of the deciduous fruits grown in California. It has not been observed on citrus trees; hence the orange growers will consider it much less pernicious than the red scale (*Aspidiotus aurantii*). For description and figures, see Agr. Report 1880, page 304.

THE RED BAY SCALE

14. Aspidiotus perseae Comstock.

This is an insect which infests the red bay (*Persea carolinensis*) in Florida. For description and figures, see Agr. Report 1880, page 305.

THE MASKED SCALE INSECT

15. Aspidiotus personatus n. sp. (Plate III, figs. 2 and 2*a*).

This is a Cuban species which infests the leaves of various trees and shrubs in the public gardens of Havana. I am indebted to Mr. B. W. Law, of that city, for the specimens from which this description is drawn.

Scale of female.— The scale of the female is circular, very convex, with the exuviae central. The scale is dark gray or black, with the exuviae shining black. The position of the exuviae is usually marked with a white dot and a concentric ring of the same color. Ventral scale well developed.

Female.— The body of the female is very thick, completely filling the unusually convex scale. The most striking characteristic of this insect, however, is a large projection of the cephalic end of the body (Plate III, fig. 2). It is this character that suggested the specific name.

The last segment presents the following characters (Plate III, figs. 2 and 2*a*):

There are no *groups of spinnerets.*

There are six pairs of *lobes.* That is, in addition to the three pairs of true lobes there are on each side three lobe-like prolongations of the margin of the segment. The lobes of each side are as follows: the first, or mesal, lobe is pointed and often bears a notch on its disto-lateral margin; the second is smaller than the first and usually bears two notches on its corresponding margin; the third is larger than the first and bears three notches; the fourth lobe is largest of all and bears from four to eight notches; the fifth is smaller than the third; and the sixth is a mere point.

There are many *thickenings of the body wall* along the margin of the last segment. Those of either side are as follows: the first and second lobes are much prolonged cephalad; the third and fourth lobes each have two shorter prolongations; between the first and second lobe is a narrow thickening which extends farther cephalad than any other; between the second and third lobe is one, which is but little shorter; between the third and

fourth lobes are two still shorter; and laterad of the fourth lobe are many very short ones.

The *plates* are short and delicate; but they are remarkably constant in shape and number. There is one between the mesal lobes which is bifurcated; two laterad of each of the mesal and second lobes, in each case the mesal plate of the two is usually bifurcated; and three laterad of the third lobe of each side, of these the mesal one is simple and the lateral two bifurcated.

There are two delicate *spines,* one on the dorsal surface and one on the ventral laterad of the sixth lobe of each side. The spines of the other lobes are obsolete or wanting.

THE ASPIDIOTUS OF PINE

16. Aspidiotus pini Comstock.

This species infests the leaves of pine. For description and figures, see Agr. Report 1880, page 306.

THE GREEDY SCALE INSECT

17. Aspidiotus rapax Comstock.

Like the pernicious scale insect (*Aspidiotus perniciosus*), this species infests many different plants; and sometimes it occurs in such great numbers as to be very destructive. This is especially the case on euonymus in hothouses in the North or in the open air in the South; and in California on olive and mountain laurel (*Umbellularia californica*). I have also found it on the following-named plants in California: almond, quince, fig, willow, eucalyptus, acacia, and locust. For descriptions and figures, see Agr. Report 1880, page 307.

From this species I bred the chalcid parasite *Aphelinus fuscipennis* Howard, described in Agr. Report 1880, page 356.

THE PALMETTO SCALE

18. Aspidiotus (?) sabalis n. sp. (Plate III, figs. 1–1*c*).

This species infests the leaves of palmetto in Florida. It was

received from Dr. Turner, of Ft. George; and I collected it at Sanford.

Scale of female.— The scale of the female is snowy white. It is irregular in outline, but approximately circular. The exuviae vary in position from central to marginal; they are covered, and their position is indicated by a tubercle which is of a deeper white than the remainder of the scale. (See Plate III, fig. 1, the larger scales.)

Female.— The body of the female is white. The last segment presents the following remarkable characters (Plate III, fig. 1*c*):

There are six groups of *spinnerets,* three on each side. The cephalic group of each side consists usually of four; the intermediate group of four to seven; and the caudal group of six to ten.

Neither *lobes* nor *plates* are present. The caudal extremity of the segment is notched so that the segment has the appearance of being terminated by a pair of lobes; but the characteristic structure of these organs is wanting. On the ventral surface there are on each side four small spines, at nearly equal distances from each other, extending from the meson to near the penultimate segment. There are also on each side more nearly on the edge of the segment about five larger spines. The openings on the dorsal surface of the segment are small, and the greater number of them are in four cephalo-caudal lines. These are represented in the figure, as they may be seen from the ventral side in a specimen prepared with caustic potash.

Rudimentary antennae are present in the female (Plate III, fig. 1*b*). The female is viviparous.

Scale of male.— The scale of the male resembles that of the female, except that it is smaller and more elongated. (See Plate III, fig. 1, the smaller scales.)

Male.— The color of the male is yellow. This sex is wingless, and has short spindle-shaped antennae, differing in form from the antennae of any other described male coccid (Plate III, fig. 1*a*).

I place this species in the genus Aspidiotus only provisionally. The absence of lobes and plates from the last segment of the female, the arrangement of the groups of spinnerets and of the openings on the dorsal surface of this segment, the absence of

wings in the male, and the peculiar form of the antennae of the male, constitute a combination of characters which I believe to be of generic importance. But I believe that a thorough revision of the genera of this family will be necessary ere long; and until that is done I think nothing is to be gained by the erection of a genus for a single species which can be placed in an existing genus.

THE SMILAX SCALE

19. Aspidiotus smilacis n. sp. (Fig. 6).

This species was collected by Professor W. Trelease at Woods Holl, Mass. It infests smilax. It is clearly allied to *A. mimosae* and *A. tenebricosus.*

Scale of female.— The scale of the female is circular, with the exuviae central and covered with excretion. It varies in color from a brown to a dark gray, almost black. The position of the exuviae is marked with a white dot and concentric ring of the same color.

Female.— The last segment presents the following characters:

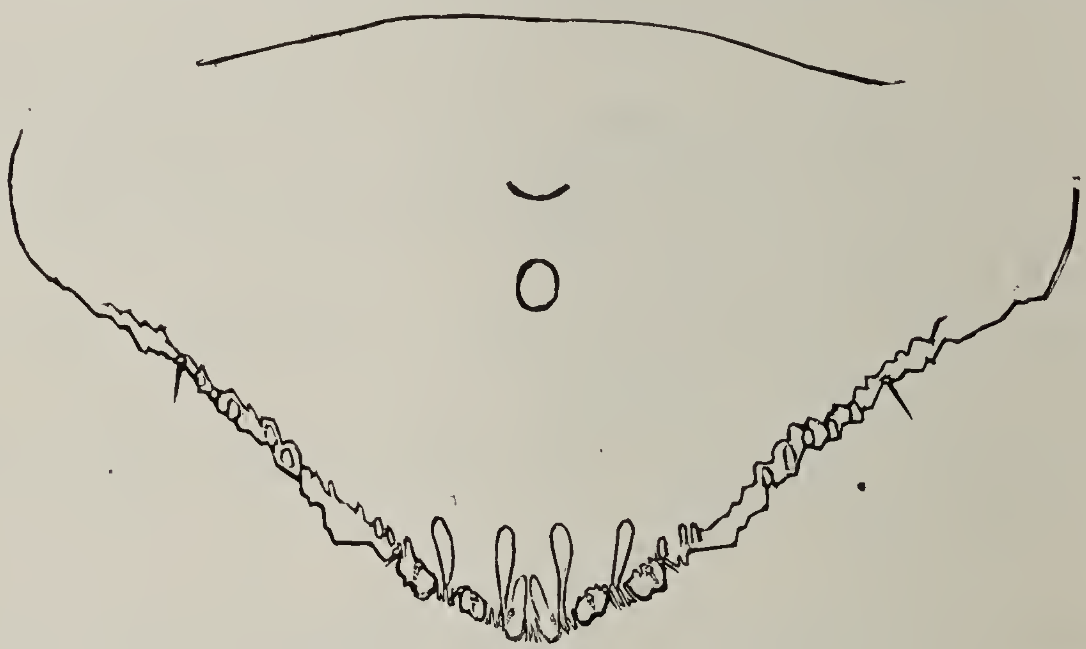


FIG. 6 (Fig. 98, Cornell series).

There are no groups of *spinnerets.*

There are three pairs of well-developed *lobes.* The mesal lobes are the smallest, and are rounded; the second lobe of each side is larger and is notched on its distal margin; the third lobe is sim-

ilar in shape to the second, but it is larger and sometimes it bears two notches instead of one. The margin of the segment laterad of the third lobes is thickened and notched many times.

There are six conspicuous club-shaped *thickenings* of the body wall, three on each side. The first of each side is a prolongation of the mesal lobe; the second is the largest and extends cephalad from a point just laterad of the base of the mesal lobe; the third, which is nearly as large as the second, extends cephalad from between the second and third lobes.

The *plates* are small and are usually notched at the distal end. There are two between the mesal lobes, and two laterad of each mesal and second lobe.

The *spines* are inconspicuous. Each lobe bears one on its dorsal surface, and on the ventral surface there is one laterad of each of the second and third lobes. There is a large slender spine a little more than halfway from the third lobe to the penultimate segment.

THE SPINED SCALE INSECT

20. Aspidiotus spinosus n. sp. (Fig. 7).

This species infests the leaves and branches of camellias in the conservatory of the Department of Agriculture.

Scale of female.— The scale of the female is circular, with the exuviae central and covered with excretion. Color of scale very light brown or dirty white.

Female.— There are four groups of *spinnerets*; the cephalo-laterals consist each of three to six, and the caudo-laterals of four to six.

FIG. 7 (Fig. 99, Cornell series)

The mesal *lobes* are quite prominent; each is suddenly narrowed on each side near the distal end. The second and third lobes are small.

The *plates* are of medium size; nearly all of them are more or less notched; there are two between the mesal lobes; two laterad of each mesal lobe; three between the second and third lobe of each side; and usually five or six laterad of the third lobe.

The *spines* on the dorsal surface of the segment are remarkable for their size. Those of each side are as follows: the first is on the lateral part of mesal lobe, and is a little longer than the lobe; the second and third are situated on the second and third lobes respectively, they are very wide, and extend far beyond the lobes; laterad of the lateral plate there is a similar spine. The three spines last described are the largest I ever saw in this genus. There is a fifth spine about midway between the fourth spine and the penultimate segment. The spines of the ventral surface are of the usual size; and excepting the first, which is obsolete, are situated in each case a short distance laterad of the corresponding spine of the dorsal surface.

This species differs from *A. camelliae* (according to Signoret's description of that species) in the great size of the spines, the presence of the groups of spinnerets, and the presence of the second and third pairs of lobes.

THE GLOOMY SCALE

21. Aspidiotus tenebricosus Comstock.

This is a species with a dark inconspicuous scale; it infests red, or swamp, maple (*Acer rubrum*) at Washington, D. C. For description and figures, see Agr. Report 1880, page 308.

THE GRAPE SCALE

22. Aspidiotus uvae Comstock.

This species infests grapevines at Vevay, Ind., and hickory in Florida. For description and figures, see Agr. Report 1880, page 309.

SPECIES OF ASPIDIOTUS NOT YET OBSERVED IN THE UNITED STATES

23. Aspidiotus offinis Targioni-Tozzetti.

Aspidiotus offinis Targ.-Tozz., Catal., p. 45.
Aspidiotus offinis Targ.-Tozz. Signoret, Essai, 1869, p. 114.

This is a species which lives in Italy on *Ruscus aculeatus,* a liliaceous plant belonging to the tribe Asparageae and known as butcher's broom, or knee holly. The following are the more important of the characters given by Targioni-Tozzetti:

The scale of the female is circular, somewhat swollen, with the exuviae central. The female is broadly obovate, rugose above and below. With six lobes, of which the four internal are the largest and are laterally incised, and two are alternating with lacerated and fimbriated scales. Two groups of lateral spinnerets (on each side?). Scale of male depressed, elongated oval.

24. Aspidiotus aloes (Boisduval).

Chermes aloes Boisduval, Ent. Hort. (1867), p. 327.
Aspidiotus aloes Boisd. Signoret, Essai, 1869, p. 114, Pl. III, fig. 1.

This species is found in Europe on the leaves of *Aloe umbellata,* a liliaceous plant resembling the agave, or century plant. The scale of the female resembles much that of *A. nerii*; it is white, circular, with the exuviae central and yellow. The female is greenish yellow, and globular. According to Signoret's figure, the cephalo-lateral groups of spinnerets consist each of four, and the caudo-laterals of nine. The mesal lobes are very large; and there is represented in the figure laterad of each mesal lobe either two incisions or well-developed second and third lobes.

Signoret states that the plants can be easily cleared of this pest by means of a brush, and kept clean by the use of limewater.

25. Aspidiotus atherospermae Maskell.

Aspidiotus atherospermae Maskell. Trans. and Proc. New Zealand Inst., XI, p. 198.

This species is found in New Zealand upon a tree indigenous to that country, the *Atherosperma novae-zealandiae.* The scale of the female is said to resemble that of *A. epidendri* but to be somewhat

darker in color (*A. epidendri* is described by the same writer as flat, of a dirty white color, sometimes brownish, with the exuviae central and yellow). The last segment of the female presents four groups of spinnerets. The cephalo-laterals consist of fifteen, the caudo-laterals of nine or ten. "The abdomen ends in several lobes of which the four middle ones are the largest. The rest of the lobes are sharply pointed. Between the lobes are scaly serrate hairs."

26. Aspidiotus betulae Bärensprung.

Aspidiotus betulae Bärensp., Journal d'Alton et Burm, 1849.
Targioni-Tozzetti, Catal., 1868, p. 43.
Signoret, Essai, 1869, p. 115.

This species infests birch in Europe. The larvae are yellow; the females wine red; the scale round and the color of the bark of birch. These scales are found under the outer loose bark.

27. Aspidiotus budleiae Signoret.

Aspidiotus budleiae Signoret, Essai, 1869, p. 115, Pl. III, fig. 2, Pl. IV, fig. A, B, D.

This species was found in the conservatories of the Luxembourg on the leaves and branches of *Buddleia salicina*, a plant belonging to the order Scrophulariaceae. The scale of the female resembles that of *A. nerii*, being circular, white, with the exuviae central and yellow; the scale of the male is elongated; both turn brown in growing old. The male is clear yellow, a little brownish on the thoracic disk; head notched in front, with four or five hairs in the notch; the thoracic band is shorter than in *A. nerii*, and the angles of the notch of the head are more rounded. The female is nearly circular, of a clear yellow, tinged with orange; the last segment presents four groups of spinnerets; the cephalo-laterals consist of five or six, and the caudo-laterals of three or four.

28. Aspidiotus caldesii Targioni-Tozzetti.

Aspidiotus caldesii Targ., Catal. (1868), p. 43.
A. caldesii Targ.-Tozz. Signoret, Essai, 1869, p. 116.

This species infests the leaves of *Daphne callina* in Europe.

The scale of the female is thin, circular, pellucid, white, with

the exuviae central. The female is broadly obovate, depressed, yellowish green, with two very large lobes and two smaller lateral lobes, and terminated by interposed lacerated and fimbriated plates. Groups of spinnerets wanting, or a few spinnerets which form inconspicuous, slightly interrupted groups. Scale of male white, very thin, elliptical.

29. Aspidiotus camelliae (Boisduval).

Kermes camelliae Boisduval, Ent. Hort., p. 334.
Aspidiotus camelliae Boisd. Signoret, Essai, 1869, p. 117.

This species occurs in various conservatories at Paris upon camellias. The scale of the female is rounded, very convex, and of a more or less transparent yellowish brown. The scale of the male is a little more elongated. The female is rounded like *A. nerii*, but of a more elongated form, and wider posteriorly. The female of this species differs from that of *A. nerii* in that the caudal extremity of the abdomen presents only a single pair of lobes, and the groups of spinnerets are wanting.

30. Aspidiotus ceratoniae Signoret.

Aspidiotus ceratoniae Signoret, Essai, 1869, p. 118, Pl. IV, fig. 2.

This species was collected at Nice on Ceratonia, a plant belonging to the order Leguminosae. It is said to differ from *A. nerii* in the form of the male in which the transverse band of the prothorax is not so pronounced, being almost invisible; the margins of the thorax are more indented; the head presents a notch in front with some hairs; the antennae are long, pubescent, with the two basal segments distinct. The intermediate tibiae, as seen from the side, are narrowed in the middle and enlarged distad; the tarsi are very large.

31. Aspidiotus chamaeropsis Signoret.

Aspidiotus chamaeropsis Signoret, Essai, 1869, p. 118.

This species infests a palm (*Chamaerops australis*). The scale is elongated, transparent, with the exuviae clear yellow and placed upon the side. The female is elongated, yellow; the extremity of the abdomen is terminated by two principal lobes and on each side three to four (*five* according to Signoret's figure) smaller ones. Each

lobe is terminated by a very long hair. There are four groups of spinnerets. The cephalo-laterals consist of three each, and the caudo-laterals of four or five. No plates are represented in Signoret's figure.

Can this be a species of Aspidiotus? The position of the exuviae, and the unusual characters of the last segment of the female, are certainly very different from anything else in this genus. I have not seen specimens.

32. Aspidiotus cycadicola (Boisduval).

Chermes cycadicola Boisd., Ent. Hort. (1867), 344.
Aspidiotus cycadicola Boisd. Signoret, Essai, 1869, p. 119.

This species infests *Cycas revoluta* in Europe. The scale of the female is circular, white, with the exuviae central and yellow. The scale of the male is a little elongated. The female is rounded, yellow; the extremity of the abdomen presents two large mesal lobes; the lateral lobes are smaller; between the lobes are plates; four groups of spinnerets; the cephalo-laterals consist each of ten to twelve, and the caudo-laterals of six to seven. The male differs from that of *A. nerii,* to which it is closely allied, by the large size of the thoracic band which reaches the wings.

33. Aspidiotus denticulatus Targioni-Tozzetti.

Aspidiotus denticulatus Targ.-Tozz., Catal. (1868), 43.

This species infests the leaves of *Rubia peregrina* in Italy. The following characters are given by Targioni-Tozzetti:

Scale of female thin and transparent. Female elongated, with the anterior lobe rounded off, with the entire lobe thinly ciliated, with the posterior triangular subtruncated, with lobes and plates lacerated and toothed, two on each side. Groups of spinnerets wanting; with eight to ten rather large scattered ones.

34. Aspidiotus destructor Signoret.

Aspidiotus destructor Signoret, Essai, 1869, p. 120.

This species occurs on the island of Bourbon in the Indian Ocean, where it is very destructive to cocoa-nut trees. It also infests palms, dates, and *Goyavius psidium* in the same locality.

The scale is circular, of a transparent white, with the exuviae

central and of a transparent yellowish white. The body of the female is circular, yellow, and presents six caudal lobes. The mesal lobes are shorter than the others. There are four groups of spinnerets, each of which consists of eight or ten.

35. Aspidiotus dysoxyli Maskell.

Aspidiotus dysoxyli Maskell. Trans. and Proc. New Zealand Inst., XI. p. 198.

This is a New Zealand species described by Maskell. From its specific name we infer that it infests some species of Dysoxylon, a genus of plants belonging to the Meliaceae, which is represented in this country by the Pride of India, or "China tree." The scale is brown, somewhat convex, the underside white. The female in the middle is bright yellow. There are four groups of spinnerets: the cephalo-laterals consist each of ten, the caudo-laterals of nine. The abdomen ends in six lobes, of which only the two median are conspicuous; between the lobes serrated plates.

36. Aspidiotus epidendri Bouché.

Aspidiotus epidendri Bouché. Ent. Zeit. Stett. (1844), V. 293.
Chermes epidendri Bouchè. Boisduval, Ent. Hort. (1867), 339.
Aspidiotus epidendri Bouché. Signoret. Essai. 1869. p. 121.

This species is found upon Epidendrum, a genus of orchids, in the conservatories of Europe. It very closely resembles *A. nerii*; in fact the only characters which have been given which will distinguish this species from that are contained in Signoret's description of the male. According to this writer, the male of this species is more elongated than that of *A. nerii*; the notch in the head is more pronounced; the costal margin of the wings is more hollowed out, and the tubercle of the abdominal style is longer. The legs are also different; the posterior legs have the femora thickened; the tibiae have a deep and long notch at the proximal end, and the tarsi are very large. Signoret gives a beautiful figure of the male (l. c., Plate IV, fig. 1).

37. Aspidiotus ericae (Boisduval).

Chermes ericae Boisduval, Ent. Hort. (1867), p. 330.
Aspidiotus ericae Boisduval. Signoret, Essai, 1869. p. 121.

The above name has been given to a scale insect found upon

heath (*Erica mediterranea*) in France. No characters have been given as yet which will distinguish this species from *A. nerii.*

38. Aspidiotus genistae Westwood.

Aspidiotus genistae Westw., Synop. Gen. Brit. Ins., 118.
Aspidiotus genistae Westw. Signoret, Essai, 1869, 122.
Aspidiotus ulicis Signoret, Essai, 1869, p. 132; 1879, p. 676.

The specific name *genistae* has been given to a species of Aspidiotus which infests Genista, a genus of leguminous plants in Europe. No characters have been given as yet which will distinguish this species from *A. nerii.*

39. Aspidiotus gnidii Signoret.

Aspidiotus gnidii Signoret, Essai, 1869, p. 122.

This species infests *Daphne gnidium* in southern Europe. Signoret states that generally it is smaller than *A. nerii.* This is the only character given in the specific description.

40. Aspidiotus hederae (Vallot).

C. hederae Vallot, Mem. Acad. Dijon (1829).
Aspidiotus hederae Vallot. Signoret, Essai, 1869, p. 122.

This species occurs in Europe upon the leaves of various evergreens, as ivy, holly, and boxwood. The scales are yellowish brown, with the exuviae central and of a clear, more or less transparent, yellow. The abdominal extremity of the female is more elongated than in *A. nerii* and terminated by six lobes, more or less developed; in the notches some simple hairs [plates]; on the disk, near the border, some spinnerets of which the base is rounded and bifid, and terminated by a very long hair. No groups of spinnerets have been observed.

41. Aspidiotus hippocastani Signoret.

Aspidiotus hippocastani Signoret, Essai, 1869, p. 136.

This species infests the horse-chestnut in Europe. The scale of the female is circular, blackish, with the exuviae central and transparent yellow; the scale of the male resembles that of the female but is elongated. The body of the female is circular, and very wide toward the anal extremity. The caudal extremity presents two

large and long lobes with a sinuosity in each side; there are four or five hairs [plates] between the lobes and the penultimate segment. There are, at least, four groups of spinnerets; the cephalo-laterals consist each of eight, the caudo-laterals of eight to ten.

42. Aspidiotus ilicis Signoret.

Aspidiotus ilicis Signoret, Essai, 1869, p. 123.

This scale insect infests a species of live oak (*Quercus ilicis*) in France. The scale of the female is larger and much more convex than that of *A. nerii*; it is grayish yellow, with the exuviae nearly marginal and sometimes forming a black point. The scale of the male is much smaller, a little elongated, and white. The female is of a clear yellow, circular, differing only from *A. nerii* in the isolated spinnerets being less numerous and more difficult to see; in the compound spinnerets being smaller, and the groups consisting of fewer, the cephalo-laterals consisting each of six, and the caudo-laterals of three. The mesal lobes are as large as those of *A. nerii,* and are nearer together; the other lobes are hardly developed; the plates are less numerous; the lateral ones are hair-like. In many individuals Signoret was unable to observe the groups of spinnerets.

43. Aspidiotus kennedyae (Boisduval).

Chermes kennedyae Boisd., Ent. Hort. (1867), 326.
Aspidiotus kennedyae Boisd. Signoret, Essai, 1869, 124.

This is an insect which infests leguminous plants of the genus Kennedya in Australia. The only character given by Boisduval is that it resembles *A. nerii* greatly except that it is a little reddish.

44. Aspidiotus lataniae Signoret.

Aspidiotus lataniae Signoret, Essai, 1869, p. 124.

This species infests Latania, a genus of African palms. The scale is a little elongated, of a clear yellow, translucid at the center, and of a dirty white at the circumference, or at least at the margin of the exuviae. The exuviae are large, and elongated in outline. The female is oval, rounded before, much elongated towards the other extremity; the mesal lobes are large; the

lateral lobes are hardly visible; there are four groups of spinnerets. The cephalo-laterals consist each of three, the caudo-laterals of six to seven; on the margin of the segment a hair [plate] or two.

45. Aspidiotus lentisci Signoret.

Aspidiotus lentisci Signoret, Essai, 1876, p. 601.

"This species resembles greatly *Aspidiotus nerii.* The male and female scales differing from that species only by their yellowish brown color, with the exuviae more clear and brilliant. As to the spinnerets we have found them too variable to enable us to describe them."

46. Aspidiotus limonii Signoret.

Aspidiotus limonii Signoret, Essai, 1869, p. 125.

This species infests lemons, and is said to differ from *Aspidiotus nerii* by the caudal lobes being more detached and more apparent and by the plates being larger; but above all by the more elongated form of the last abdominal segment. The scale of the female is circular, yellowish white, with the exuviae central and yellow; that of the male is more elongated.

47. Aspidiotus myrsinae Signoret.

Aspidiotus myricinae Signoret, Essai, 1869, p. 125.
Aspidiotus myrsinae Signoret, Essai, 1876, p. 670.

This species occurs upon *Myrsina retusa* in the conservatories of the Luxembourg. It is closely related to *A. nerii* in all respects, but differs from that species by the more elongated form of the body, by the more pronounced protuberances or sinuosities on the margin of the body opposite the mouth, and by the smaller number of the compound spinnerets; the cephalo-lateral groups consisting each of four or five, and the caudo-laterals of three or four.

48. Aspidiotus niger Signoret.

Aspidiotus niger Signoret, Essai, 1869, p. 130.

This species infests willow in France. The scale of the female is circular, black, and with the exuviae yellow; the scale of the male is elongated and of the same color. The female is brownish

yellow. The margin of the last segment presents only two lobes and on each side five or six small spiny hairs [plates]. No groups of spinnerets.

49. Aspidiotus oxyacanthae Signoret.

Aspidiotus oxyacanthae Signoret, Essai, 1869, p. 137.

This species infests the English hawthorn (*Crataegus oxyacantha*). The scales are blackish gray, with the exuviae transparent yellow. The scale of the female is circular, that of the male elongated. The extremity of the female presents two quite large lobes with a sinuosity on each side and four or five spiny hairs [plates]. There are five groups of spinnerets. The mesal group consists of four or five; the other four groups, each of ten to twelve.

50. Aspidiotus phormii Breme.

The species is found in Switzerland, upon *Phormium tenax,* a liliaceous plant which furnishes the so-called New Zealand flax. Signoret states (Essai, 1869, p. 130) that the scale of the female is white, circular, with the exuviae central, that of the male a little more elongated. I find no description of the insect itself.

51. Aspidiotus pandani Signoret.

Aspidiotus pandani Signoret,* Essai, 1869, p. 131.

This species is said to live exclusively upon *Pandanus utilis,* an agave-like plant from India. It resembles *A. nerii* much in form, but differs in color, being a blackish brown, with the center whitish. The male has not been described. The female, circular, whitish yellow in color, and presents on the caudal segment four groups of spinnerets. The cephalo-lateral groups consist each of four or five, and the caudo-laterals of three. The yellow color of the female is more or less deep according to age. The segmentation of the body is hardly indicated. The caudal segment

* Signoret describes this species as "*Aspidiotus pannani* Boisduval" (Essai, 1869, p. 131). This is evidently a slip of the pen, as the species is twice referred to in the same monograph (Essai, 1868, p. 863, and 1876, p. 671) as *Aspidiotus pandani* Signoret; and I am unable to find any reference to it in the writings of Boisduval.

presents on its border two mesal lobes, and on each side two lateral lobes. The latter are separated by quite large notches, and in the notches are well-developed plates, the lateral margins of which are serrate. Between the caudal margin and the groups of spinnerets are ten spines, and cephalad of the groups of spinnerets extending in a line across the segment are five groups of what appear to be, according to Signoret's figure, filiform wax ducts.

52. Aspidiotus palmarum Bouché.

Aspidiotus palmarum Bouché, Naturg. Ins. (1834), 1, 17; 5.
Aspidiotus palmatum Blanch., Hist. Nat. (1840), III, 215.
Aspidiotus palmarum Bouché. Signoret, Essai, 1869, 131.

In conservatories and in the open air in southern Europe a species of Aspidiotus is found upon palms which has received the specific name of *palmarum*. According to Signoret the species resembles *A. nerii* very much. The scales are white with the exuviae reddish yellow; those of the female are circular, those of the male elongated. The female is broadly rounded. There are four groups of spinnerets; the cephalo-laterals consist each of ten, the caudo-laterals of seven to eight. Between the caudal margin and the groups of spinnerets are isolated spinnerets [wax ducts] in the form of a tube as with *A. nerii.* The male is larger and more elongated than that of *A. nerii*, and the middle and posterior feet are more sinuous and more notched than in that species.

53. Aspidiotus quercus Signoret.

Aspidiotus quercus Signoret, Essai, 1869, 132.

Upon the leaves and trunk of oak Signoret found a species of Aspidiotus which he described under the name *quercus*. The scales are of a grayish white on the trunk, but a little yellowish upon the leaves. Those of the female are circular, those of the male much elongated, with the exuviae central and yellow. The female is broadly rounded, with four caudal lobes, and on each side some spiny hairs [plates]. There are no groups of spinnerets. The male is short, and of a milky white color. The antennae are short, pubescent; the fourth, fifth, and sixth segments are the largest; the others are almost globular. The head is notched in front, and there are four or five hairs in the notch.

54. Aspidiotus spurcatus Signoret.

Aspidiotus spurcatus Signoret, Essai, 1869, p. 138, Pl. IV, fig. 8.

This species was found by Signoret upon poplar in France. The scale of the female is circular, blackish brown in color, with the exuviae clear yellow. The female is large and circular; when the body is filled with eggs the abdominal segments almost disappear while the head and "breast" become very large. The caudal segment presents five groups of spinnerets, each consisting of a small number, especially the mesal, which consists of only five or six at the most. The mesal lobes are well developed. There are on each side two notches and four or five spine-like plates. The scale of the male is elongated. The male is blunt, short, with short and rounded wings, with short and hairy antennae, and with the thoracic band black. The posterior tibiae are strongly notched near the distal end; and the tarsi are large, flat, and pubescent.

55. Aspidiotus signoreti Comstock (Fig. 8).

Targionia nigra Signoret, Essai, 1870, 106.

Signoret in his monograph of this family (1870, p. 105) establishes the genus Targionia for a species of the Diaspinae which has a complete shell, and describes the species under the name *Targionia nigra*. This species cannot, however, be separated from Aspidiotus. Several species of Aspidiotus have a well-developed ventral scale, so that it may be said that they have a complete shell. Thus in *A. tenebricosus* the ventral scale closely resembles that of the species described by Signoret as *Targionia nigra*. In *A. aurantii* it is more delicate, but in the adult it is so well developed and adheres so firmly to the dorsal scale that it is very difficult to remove the insect from its shell. In *A. rapax* the ventral scale is usually entire and quite conspicuous. In fact we find that in the genus Aspidiotus the ventral scale varies from an imperceptible film to a thickness as great as in Targionia. And as it is impossible to separate those species having a thick ventral scale, or, in other words, those having a complete shell from those that do not, we are forced to the conclusion that the genus Targionia is not a natural one, and that the species described as *T. nigra* must be

placed in Aspidiotus. But the name *nigra* is preoccupied in this genus; I therefore propose the name *signoreti* in honor of the discoverer of this interesting species.

Aspidiotus signoreti infests *Cineraria maritima* (a plant belonging to the Compositae) in France. The scale of the female is black, very convex, rounded, with the exuviae central.

FIG. 8 (Fig. 100, Cornell series)

Figure 8 represents the last segment of the female. The figure was made from specimens kindly furnished me by M. Signoret.

56. Aspidiotus tiliae Signoret.

Aspidiotus tiliae Signoret, Essai, 1869, 137, Pl. IV, fig. 7.

Upon linden or basswood in Europe is found a species of Aspidiotus which is described by Signoret as follows: It resembles *A. nerii,* but may be distinguished from that species by there being only two caudal lobes. The scale of the female is circular, of a deep dirty gray, and with the exuviae central. The female is circular; the caudal segment presents five groups of spinnerets; the mesal group consists of seven or eight, the others of nine to ten each. The border of the segment presents two large median lobes, with some simple sinuosities, and five or six very small spines on each side.

57. Aspidiotus villosus Targioni-Tozzetti.

Aspidiotus villosus Targ.-Tozz., Catal. (1868), 43.
Aspidiotus villosus Targ. Signoret, Essai, 1869, 133, Pl. IV, fig. 6.

This species infests the leaves of olive in Europe. Targioni-Tozzetti gives the following characters: Scale of female circular, grayish, depressed, hairy, exuviae eccentric. Female depressed, with the anterior lobe largest, rounded off. The posterior lobe short, triangular with an obtuse apex.

Signoret states that the groups of spinnerets consist of three each, that there are only two lobes, and that the body is wider towards the caudal end than towards the head.

58. Aspidiotus vitis Signoret.

Aspidiotus vitis Signoret, Ann. Soc. Ent. Fr., Bull. p. LII (1876).
Aspidiotus vitis Signoret, Essai, 1876, 601.

This species infests grapes in the vicinity of Nice, and was found upon raisins from Algiers. The scales are dark gray in color; the exuviae are central and more or less covered. When rubbed the exuviae are brilliant black. The color of the scale is similar to that of the old bark of the vine, so that the presence of the insect is not easily detected except by the white ventral scale which adheres to the plant after the insect has been removed. The female is circular, of a deep grayish brown, with the abdominal extremity clear yellow. Groups of spinnerets were not distinguishable. There is only a single pair of lobes, which are very small; on each side of the lobes are two quite long hairs, and between them and the penultimate segment two smaller ones. The male is of a uniform dark yellow, with the thoracic band dark brown, the eyes black, the wings very long, extending beyond the extremity of the style. The style is long, equaling in length the distance from the thoracic band to the extremity of the last abdominal segment. The antennae are thick and pubescent; the fourth segment is the longest; the third is next; the fifth to the ninth are a little longer than wide, and of equal length; the tenth is very small, hardly longer than the first, which with the second are the smallest.

59. Aspidiotus vriesciae Signoret.

Aspidiotus vriesciae Signoret, Essai, 1869, 134.

In conservatories upon the leaves of *Vriescia splendens,* a plant belonging to the Bromeliaceae, is found this species, which Signoret describes as follows: It is closely allied to *A. nerii,* but is distinguished from that species by the more elongated form of the scales, and the fact that the scales of both sexes are of a uniform yellowish gray. The female is more elongated, less rounded, with the notches deeper, still one can see well only the two mesal lobes, which are large, with one harder, a little indented. There are but few spinnerets in the groups.

60. Aspidiotus zonatus Frauenfeld.

Aspidiotus zonatus Frauenf., Verh. Zool. Bot. Ges. Wien, 1868, 888.
Aspidiotus zonatus F. Signoret, Essai, 1869, 135.

This species was found on an American oak (*Quercus montana*), in the Botanical Garden at Vienna. From the description it is evident that only the males and male scales were seen. The scales when full-grown are 1.8 mm. in length, white with a yellow zone around the side, which is a little elevated. The adult male is yellow with the thoracic band dark red.

Genus **DIASPIS** Costa

Costa Fauna di Napoli, 1836

This genus includes species of Diaspinae in which the scale of the female is circular or nearly so, with the exuviae either central or more or less marginal, and the scale of the male long, white, carinated,* and with the larval skin at one extremity. The last segment of the female presents five groups of spinnerets.

In the scale of the female the exuviae may be either central or marginal or situated at any point between the center and the margin. When the exuviae are central the scale resembles that of these species of Aspidiotus in which the exuviae are naked (e. g., *Aspidiotus nerii*, see Plate II, fig. 2). In such cases the species can be distinguished from Aspidiotus by an examination of the scale of the male, which is carinated in this genus and not in Aspidiotus. When the exuviae are marginal there is nothing to distinguish the species from Chionaspis except the more nearly circular form of the scale of the female in Diaspis; the form of the scale of the male being the same in the two genera. As illustrating this point, compare figure 3 of Plate II with figure 4 of the same plate. Each one is from a camera lucida drawing, the former of *Diaspis rosae*, the latter of *Chionaspis furfurus*. The difference certainly seems very slight, and, as the outline of the scale of the

* In *Diaspis minima* Targ.-Tozz., the scale of the male is said to be without carinae.

female in certain species of each of these genera is very irregular, one can imagine a case in which it would be difficult to determine to which of the two genera a species belonged. But, in fact, I have yet to meet a case where there is any difficulty in distinguishing between Diaspis and Chionaspis.

Six species of Diaspis have been observed in this country. They may be distinguished by the following table:

DIASPIS

Characters from the last segment of the female

A. Groups of spinnerets nearly continuous. **rosae.**
AA. Groups of spinnerets distinct.
  B. Margin of segment with incisions. **ostreaeformis.**
  BB. Margin of segment without incisions.
    C. The third pair of lobes obsolete or wanting. **carueli.**
    CC. With three or four pairs of lobes.
      D. Mesal lobes attached to segment throughout the entire length of their lateral margins. **boisduvalii.**
      DD. Distal extremity of mesal lobes free.
        E. Elongated pore between fifth and sixth plates on a large pointed prolongation of the body. **bromeliae.**
        EE. Elongated pore between fifth and sixth plates on a more or less rounded and inconspicuous prolongation of the segment. **cacti.**

BOISDUVAL'S SCALE

61. Diaspis boisduvalii Signoret (Fig. 9).

Diaspis boisduvalii Signoret, Essai, 1869, p. 432.

In the conservatory of the Department of Agriculture, on the lower surface of the leaves of a plant known as the traveler's joy (*Ravenala madagascariensis*) and upon a species of Livinstonia, I found a white scale in great numbers. This insect proved to be the *Diaspis boisduvalii* described by Signoret, and which he found infesting the various species of orchids in the conservatories of the Luxembourg. It is probable therefore that this species will be found infesting a variety of plants in greenhouses, and perhaps

even in the open air in the South. The presence of this pest upon the plant was easily detected by discolored spots which it produced in the leaves. These spots are at first yellowish, afterwards becoming dark brown. This insect may be distinguished from the other species of Diaspis which are known to occur in this country by the fact that the scales of the male occur massed in great numbers and the masses are covered with a quantity of loose white hairs.

Scale of female.— The scale of the female is circular or a little elongated, with the exuviae nearly central. The color of the scale varies from white to yellowish gray; the color of the exuviae is similar to that of the scale; in some specimens they are a shade darker. Diameter of scale, 2 mm. (.08 inch).

Female.— The color of the female is lemon-yellow, with the caudal end of the last segment pale brown; the outline of the body is a broad oval, each cephalo-lateral angle of the body is prolonged into a pointed projection. The last segment of the body presents the following characteristics:

FIG. 9 (Fig. 101, Cornell series)

The mesal group of *spinnerets* consist of from eight to fifteen; the cephalo-laterals of from twenty-two to twenty-nine, and the caudo - laterals of from fifteen to eighteen.

The mesal *lobes* are large, wing-shaped, separated at their base, divergent, and attached to the body throughout the entire length of their lateral margins. The second and third lobes of each side are bifurcated; the lobules are subequal and nearly parallel. The fourth lobe is present although rudimentary; its margin is serrate.

The *plates* are simple and spine-like. The first, second, third, and fourth plates are laterad of the first, second, third, and fourth lobes respectively. There are four or five plates, subequally distant from each other, between the fourth plate and the penultimate segment; these plates appear very much like tubular spinnerets.

The *spines* of the ventral surface are situated as follows: the first pair, which are large, project caudad between the mesal lobes; the second and third are mesad of the second and third plates respectively; the fourth between the fourth and fifth plates; and the fifth between the seventh and eighth plates. On the dorsal surface there is a small spine laterad of the caudal end of each mesal lobe; the second and third spines are on the lateral lobules of the second and third lobes respectively; the fourth is mesad of the fourth plate; and the fifth between the sixth and seventh plates.

Laterad of each of the first, second, and third plates the margin of the body is prolonged into a papilla which bears an elongated pore. And between the fifth and sixth plates there is a conspicuous pointed projection, which in color and apparent texture resembles the lobes; this also bears an elongated pore.

Egg.— The eggs are lemon-yellow. A single observation indicates that about sixty eggs are laid by a single female.

Scale of male.— The scale of the male is strongly tricarinated. As indicated above, these scales frequently occur massed in great numbers, and these masses are covered with a quantity of loose curled white hairs. Mixed with these hairs and scattered over the scales is usually a considerable quantity of white powdery substance.

Male.— The color of the male is dark orange; the eyes are dark purple, almost black. The antennae are very long and slender, with the segments of nearly uniform size except the first two and the last.

A large number of the males when they issued became crippled by the woolly secretion which prevented the wings from expanding. It is difficult to see the use of this woolly substance.

The male larvae and pupae resemble the adult in color.

THE PINEAPPLE SCALE

62. Diaspis bromeliae (Kerner) (Fig. 10).

Coccus bromeliae, Naturgeschichte der *Coccus bromeliae,* Stuttgart, 1788.
C. bromeliae, Bouché, Ent. Zeit. Stettin (1844), 295.
C. bromeliae, Bouché, Boisduval, Ent. Hort. (1867), 334.
Diaspis bromeliae, Kerner, Signoret Essai, 1869, 434.

Upon pineapple (*Ananassa sativa*) growing in the conservatory of the Department of Agriculture at Washington and upon *Bilbergia zebrina,* an ornamental plant belonging to the same natural order as the pineapple, I found a species of Diaspis which I believe to be the one which has been so destructive to pineapples in hothouses in Europe. The descriptions in the books of the European species are so general that I do not feel perfectly sure of the identity of our species with that; still I think there is but little doubt.

Boisduval* speaks of this insect as a scourge in the hothouses where pineapples are cultivated, and states that almost always it is necessary to destroy the infested plants in order to avoid contagion, as it is impossible to remove the insects with a brush when they settle within the sheaths of the leaves. But the same writer also states that at Berlin and in Russia they destroy this insect in the pineapple hothouses by using limewater.

Scale of female.— The scale of the female is circular with the exuviae nearly marginal. The scale is white; the exuviae are very light yellow. The first larval skin is usually naked, the second covered with a delicate film. Diameter of scale, 2 to 2.4 mm. (.07 to .09 inch).

Female.— The body of the female is broadly ovate in outline; it is variable in color; it is usually a pale dirty yellow with a faint tinge of purple; some are whitish yellow with irregular pale purplish markings, and others are of a reddish yellow tint. The last segment presents the following characters:

* Essai sur l'Entomologie Horticole, p. 335.

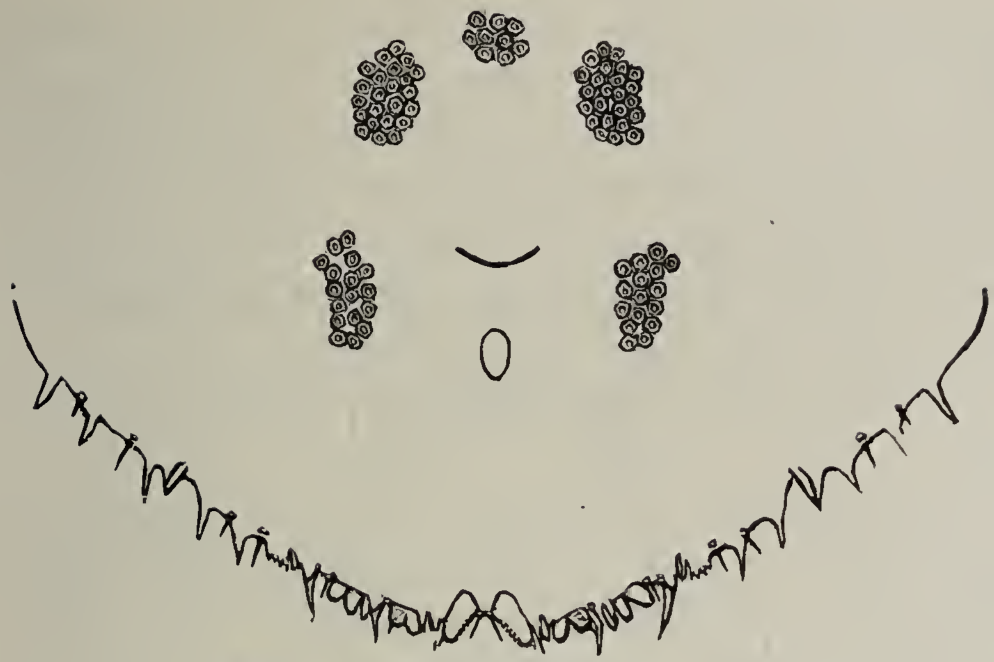


FIG. 10 (Fig. 102, Cornell series)

The mesal group of *spinnerets* consists of from nine to fifteen, usually ten or eleven; the cephalo-laterals, of from twenty to twenty-seven, usually twenty-three; the caudo-laterals of from fifteen to twenty-three, usually sixteen or seventeen.

The mesal *lobes* are small, separated at their base by at least the width of one of them and divergent. In shape and position these lobes resemble much those of *D. boisduvalii* except that the lateral margins of these are not attached to the body throughout their entire length as in *D. boisduvalii.* The second and third lobes of each side are deeply bifurcated, with the lobules divergent; in each case the lateral lobule is more rounded than the mesal one. The fourth lobe is present but much less developed than the other lobes; the lateral margin of this lobe is serrate.

The *plates* are simple and pointed. The first, second, third, and fourth of each side are laterad of the first, second, third, and fourth lobes respectively. There are four or five plates subequally distant from each other between the fourth plate and the penultimate segment.

The *spines* of each side on the ventral surface are situated as follows: first mesad of the first lobe; second, third, and fourth laterad of the second, third, and fourth lobes respectively; and the fifth between the seventh and eighth plates. All the ventral spines are very minute except the first pair, which are very conspicuous.

Of the dorsal spines the first is very delicate and is situated laterad of the first lobe; the second is large and is on the second lobe near its lateral margin; the third and fourth are laterad of the third and fourth lobes respectively; and the fifth is about midway between the sixth and seventh plates.

Between the fifth and sixth plates there is a triangular *prolongation* of the body, which bears an elongated pore.

The penultimate and antepenultimate segments bear plate-like spinnerets.

Egg.— The eggs are yellow; those recently deposited are paler than those ready to hatch. Our observations indicate that a single female lays about one hundred and fifty eggs.

Larva.— The recently hatched larvae are orange-yellow with the eyes dark purplish.

Scale of male.— The scale of the male is strongly tricarinated; the exuviae are yellow.

Male.— The body of the male is orange-yellow; the legs and antennae are light yellow; and the eyes are black. The full-grown larva of this sex is of a dark orange color with very dark purplish eyespots. The last segment is almost colorless; it is narrow, broadening slightly toward the end. The pupa is also orange, with dark purplish eyes and colorless members.

Described from ten females, two males, and many scales of each sex.

Natural enemies.— Many of the scales of the male are pierced with a hole, evidently made by a parasite, which is probably a chalcid.

THE DIASPIS OF CACTUS

63. Diaspis cacti n. sp. (Fig. 11).

In a conservatory at Ithaca, N. Y., I found an undescribed species of Diaspis infesting the cactuses. This insect occurred so abundantly as to necessitate the throwing away of a large number of these plants.

Scale of female.— The scale of the female is circular, with the exuviae nearly central. The color of the scale varies from grayish

white to light green. The exuviae are dark brown, contrasting strongly in color with the remainder of the scale. Diameter of scale, 1.7 mm. (.06 inch).

Female.— The outline of the body of the female is circular; the color is white, tinged with greenish yellow, and with the caudal end brown. The last segment presents the following characters:

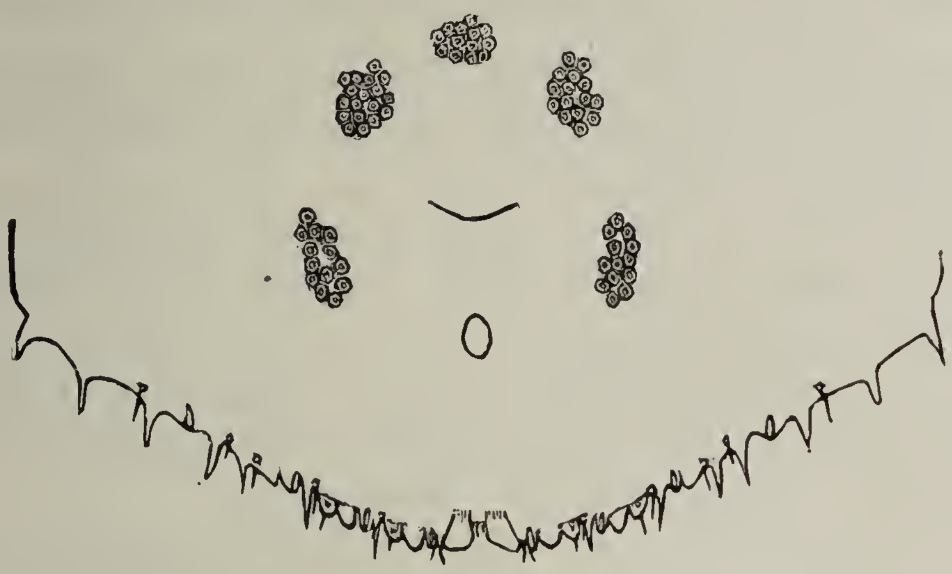


FIG. 11 (Fig. 103, Cornell series)

The mesal group of *spinnerets* consists of from six to thirteen, usually thirteen; the cephalo-laterals, of from thirteen to twenty-two; and the caudo-laterals of from nine to fifteen, usually fourteen.

The mesal *lobes* are small, with their margins entire; they are widest near the middle of their length, and from that point diverge caudad. The second and third lobes of each side are bifurcated; the lobules are subequal and parallel. A rudimentary fourth lobe is present with its margin usually entire, sometimes more or less serrate.

The *plates* are rather stout and conical. The first, second, third, and fourth are laterad of the first, second, third, and fourth lobes respectively; the fourth and fifth are usually nearer each other than any other two; the sixth, seventh, and eighth are usually at subequal distances from each other, although in some specimens two are grouped together.

The *spines* of the ventral surface are usually small in this species, while those of the dorsal surface are large. Those of the ventral

surface are situated as follows: the first pair are between the mesal lobes, but are not so conspicuous as is usual in this genus; the second and third are on the mesal part of the base of the second and third plates respectively; the fourth is between the fourth and fifth plates; we have been unable to discover a sixth ventral spine in this species. On the dorsal surface the first spine is laterad of the first lobe; the second and third, on the lateral part of the lateral lobules of the second and third lobes respectively; the fourth, mesad of the fourth plate; and the fifth, usually laterad of the sixth plate.

Laterad of each of the first, second, and third plates the margin of the body is prolonged into a papilla which bears an elongated pore.

There is a larger projection bearing an elongated pore, between the fifth and sixth plates; this projection is not nearly so long nor pointed as in *D. ananassae* and *D. boisduvalii.*

Scale of male.— The scale of the male is unicarinated, the lateral carinae being obsolete or wanting; the color of the exuviae vary from a transparent yellowish to brown.

Male.— The male has not yet been observed.

Described from twenty females, and many scales of each sex.

There is a closely allied species described by European authors, which also infests cactuses, the *Diaspis calyptroides* of Costa. The two species may be separated by the following table. The characters of *D. calyptroides* are drawn from the excellent description given by Signoret.

D. CACTI	D. CALYPTROIDES
Body of female white tinged with greenish yellow.	Body of female of an orange-red.
Cephalo-lateral group of spinnerets oval or round.	Cephalo-lateral group of spinnerets elongate.
Caudo-lateral group of spinnerets elongate.	Caudo-lateral group of spinnerets more rounded.
Mesal group consisting of six to thirteen spinnerets, usually thirteen.	Mesal group of six to seven.
Cephalo-laterals of thirteen to twenty-two.	Cephalo-laterals of sixteen to eighteen.
Caudo-laterals of nine to fifteen, usually fourteen.	Caudo-laterals of sixteen to eighteen.

Natural enemies.— I have bred a chalcid parasite from *Diaspis cacti,* a species of Aphelinus.

THE JUNIPER SCALE

64. Diaspis carueli Targ.-Tozz.

Diaspis carueli Targioni-Tozzetti, Catal. (1868).
D. carueli Targ.-Tozz. Signoret, Essai, 1869, p. 436.

This insect is very common at Washington, D. C., on various species of juniper and allied plants. For description and figures, see Agr. Report 1880, page 310. In fifth line from bottom of page 310, for Plate XX read Plate XXI.

Natural enemies.— This species is infested by the chalcid parasite *Aphelinus mytilaspidis* LeBaron, which is described and figured in Agr. Report 1880, page 354 (Plate XXIII, fig. 1).

THE PEAR TREE OYSTER SCALE

65. Diaspis ostreaeformis (Curtis).

Aspidiotus ostreaeformis Ruricola [Curtis], Gardeners' Chronicle, 1843, p. 803.
Aspidiotus circularis Fitch, Annual Report N. Y. State Agr. Society, 1856, p. 426.

This is a common species on apple and pear in England; and this year I have received it from the Chief Executive Horticultural Officer of California, Mr. Matthew Cooke, who found it infesting pear trees at Sacramento. It is probable that it occurs also in the Eastern States, as Signoret states that it is the species found by Fitch in New York and described by him under the name of *Aspidiotus circularis.* There is no specimen of the *A. circularis* of Fitch in the collection of the New York State Agricultural Society, and the type in the private collection of Fitch is merely a fragment of a scale gummed to a card. From this fragment it would be impossible to recognize the species. We are therefore forced to accept the conclusion of Signoret, which in all probability is correct, as he corresponded with Dr. Fitch and received specimens of Coccidae from him. For description and figures of this insect, see Agr. Report 1880, page 311.

THE ROSE SCALE

66. Diaspis rosae (Sand.).

Aspidiotus rosae Sandberg (1784), Abhand. Priv. Boh., no. 6, p. 317.
Diaspis rosae Signoret, Essai, 1869, p. 441.

This is a common white scale of the rose which is very widely distributed both in Europe and in this country. I have found it also on raspberries and blackberries. For descriptions and figures, see Agr. Report 1880, page 312.

SPECIES OF DIASPIS NOT YET OBSERVED IN THE UNITED STATES

67. Diaspis blankenhorni Targ.-Tozz.

Diaspis blankenhorni Targioni-Tozzetti, Soc. Ent. Ital. Resocanti, 1879, p. 17.

I have not been able to see the description of this species.

68. Diaspis calyptroides Costa.

Diaspis calyptroides Costa (1827), Faun. Nap., Pl. 6, fig. 2.
Aspidiotus echinocacti Bouché, Schadl. (1833), 53, 3.
D. calyptroides Costa. Signoret, Essai, 1869, p. 434.

This is a very abundant species upon cactuses in Europe, where it has probably been introduced from Mexico. Doubtless the species occurs in conservatories in this country, but I have not yet met it. For the characters by which it may be recognized, see comparison of this species with *Diaspis cacti*, page 93 above.

Targioni-Tozzetti states that the species described by Bouché under the name of *Aspidiotus echinocacti* is identical with this.

69. Diaspis cymbidii Bouché.

Aspidiotus cymbidii Bouché, Ent. Zeit. (1844), V. 296.
Diaspis cymbidii Bouché. Signoret, Essai, 1869, p. 436.

This is a species which infests Cymbidium, a genus of tropical orchids. The description given by Bouché is so general that it only enables one to determine the genus of this insect.

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70. Diaspis juniperi (Bouché).

Aspidiotus juniperi Bouché, Ent. Zeit. Stett., 1851, XII, 111.
Diaspis juniperi Targioni, Cat.

This is a species which infests juniper (*Juniperus communis*) in Europe. Targioni-Tozzetti states that it is distinct from his *D. carueli*; but I know of no description which gives any important characters of the species described by Bouché.

71. Diaspis leperii Signoret.

Diaspis leperii Signoret, Essai, 1869, p. 437.

This is a species which infests peach in Europe. The scale of the female is yellowish gray, with the exuviae yellow, and more or less central. The mesal group of spinnerets consists of eight, the cephalo-laterals of from twelve to thirteen, and the caudo-laterals of eight. The scale of the male is unicarinate. This species will probably be found in this country.

72. Diaspis minima Targ.-Tozz.

Diaspis minima Targioni-Tozzetti, Catal. (1868), 43.
D. minima Targ. Signoret, Essai, 1869, p. 438.

This species infests arbor vitae in Europe. It is evidently very closely allied to *Diaspis carueli*, but is readily distinguished from that species by the form of the scale of the male, which is described as being without carinae. Signoret states that it is the smallest species known to him.

73. Diaspis visci Schrank.

C. visci Schrank (1781), Enum. Ins. Aust., 296, 588.
Aspidiotus visci Loew, Verh. Zool. Bot. Gesells. zu Wien, XII, 110.
Diaspis visci Schrank. Loew, Verh. Zool. Bot. Ges., XXII, 273.

In Europe on the true mistletoe (*Viscum album*) there is found a species of Diaspis which presents the following characters: The scale of the female is circular with the exuviae central; the scale is white; the exuviae dark yellow or brown. The mesal group of spinnerets consists of from ten to twelve, the cephalo-laterals of from eleven to twelve, and the caudo-laterals of from nine to ten. In the figures given by Loew* only two pairs of lobes are indi-

* Verh. Zool. Bot. Gesells., XXII (1872), Taf. IV.

cated, and the plates are represented as being simple, pointed, and unusually large. The plates are also unusually numerous; in the more carefully drawn figure, seventeen are represented on one side and twenty on the other. The scale of the male is unicarinate.

Genus **CHIONASPIS** Signoret

Signoret, Essai, 1869, p. 442

This genus includes species of Diaspinae in which the scale of the female is long, usually much widened, and with the exuviae at one extremity; the scale of the male is white, carinated (except in *Ch. ortholobis*), with the side parallel, and the larval skin at the cephalic end. The last segment of the female presents five groups of spinnerets.

The scale of the female is always elongated but the outline may be either more or less irregular, as in *Ch. furfurus* (Plate .II, fig. 4), or regular, as in *Ch. pinifolii* (Agr. Report 1880, Plate VI, fig. 2*b*). In the former case it may approach Diaspis; but, as indicated elsewhere, I know of no case in which the scale of a Chionaspis is round enough to be mistaken for a Diaspis, or a Diaspis which is elongated enough to be mistaken for a Chionaspis. In the second case, where the outline is regular, the scale resembles that of a Mytilaspis in shape; but the generic position of the species can be determined by a glance at the scale of the male, which is white and carinated in Chionaspis, and neither white nor carinated in Mytilaspis. In fact, these two genera can in almost all cases be distinguished by the color of the scale. I know of no Mytilaspis in which the scale of either sex is white; and excepting the females of *Ch. euonymi* and *Ch. ficus,* I know of no Chionaspis in which the scale of either sex is not white.

Our species of Chionaspis may be determined by the following table:

A. Scale of female black or blackish brown.

B. Female with groups of spinnerets; plates in twos. **euonymi.**

BB. Female without groups of spinnerets; plates single. **citri.**

AA. Scale of female white or grayish white.

C. Scale of female resembling Mytilaspis in form (i. e., narrow).
  D. Exuviae naked; infesting conifers. **pinifolii.**
  DD. Second skin more or less covered; infesting grasses. **spartinae.**
CC. Scale of female typical (i. e., much widened).
  E. Last segment of female with single mesal lobe. **quercus.**
  EE. Last segment of female with a pair of mesal lobes.
    F. Body of female yellowish or brownish.
      G. Last segment of female with two club-shaped organs cephalad of mesal lobes. **biclavis.**
      GG. Last segment of female without club-shaped organs. **nyssae.**
    FF. Body of female reddish or purple.
      H. Mesal lobes short, broad, and rounded, being nearly circular (Agr. Report 1880, Plate XVI, fig. 3); a single plate laterad of each second and third lobe. **furfurus.**
      HH. Mesal lobes longer.
        I. Distal ends of mesal lobes pointed or obscurely trilobed (Plate X, fig. 4); a single plate laterad of each second lobe, and usually two plates laterad of each third lobe. **lintneri.**
        II. Distal ends of mesal lobes rounded, usually two plates laterad of each second and third lobe (Agr. Report 1880, Plate XVI, figs. 5 and 6).
          K. Mesal lobes parallel; scale of male without carinae. **ortholobus.**
          KK. Mesal lobes diverging; scale of male tricarinated. **salicis.**

THE MINING SCALE

74. Chionaspis (?) biclavis n. sp. (Fig. 12, and Plate II, fig. 11).

The species for which I propose the specific name *biclavis* and the popular name *the mining scale* occurs in considerable num-

bers in the conservatory of the Department of Agriculture. It has been found upon the following-named plants: *Diospyrus ebenum, Ficus laurifolia,* a species of Tamarindus, and, according to my notes, upon two plants labeled *Ochras sapota* and *Etaecarpus cyanus,* respectively.

This species, of which only the female is known, is remarkable on account of its habit of burrowing beneath the epidermal layer of the leaf or twig which it infests. The color of the scale is white; but this color is almost invariably obscured by the layer of vegetable tissue beneath which the scale is, and which adheres closely to the scale. Figure 11 of Plate II represents a scale taken from a leaf of fig. The position of one of these scales is indicated only by a rust-red elevated spot on the leaf, the dermal layer of the leaf with its hairs being continuous over the surface of the scale. The scales were most abundant on the twigs of *Diospyrus ebenum,* which in some instances were nearly completely covered by it.

Scale of female.— The scale of the female is very nearly circular. On this account I place the species in this genus only provisionally, until the scale of the male is found. The exuviae are marginal and project beyond the edge of the scale, giving the whole scale more nearly the form of Chionaspis than of any other known genus.

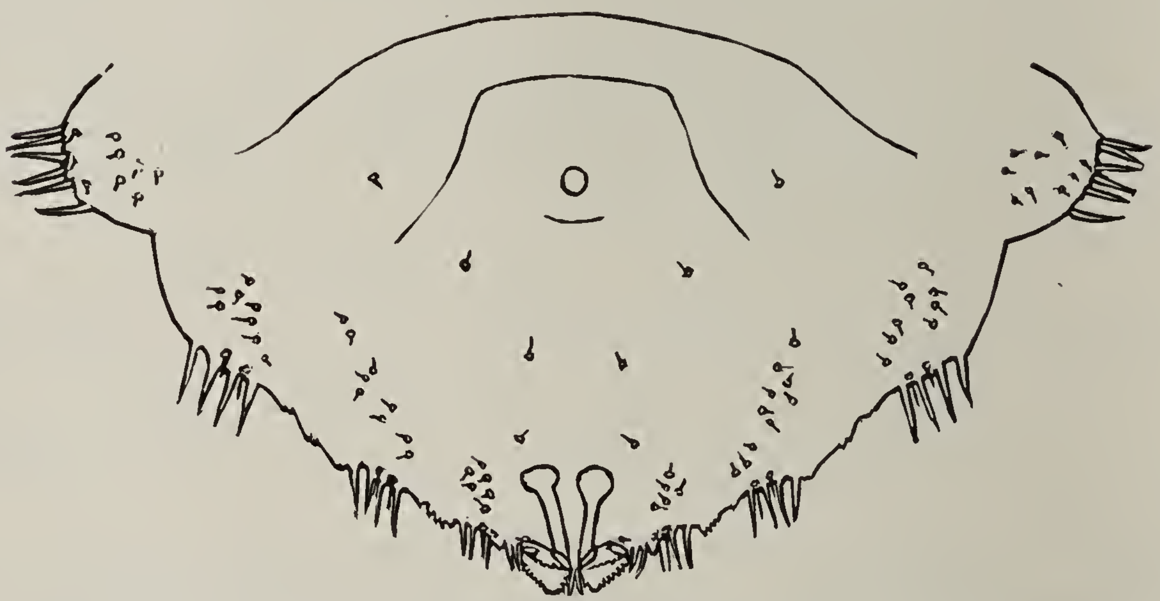

FIG. 12 (Fig. 104, Cornell series)

Female.— The characters presented by the last segment of the female (Fig. 12) are as unusual as those presented by the scale. The pores on the dorsal surface of the segment are very small. Scattered over the ventral surface are numerous minute spines. The *groups of spinnerets* are wanting.

The mesal *lobes* are large, oblique; nearly twice as broad as long; approximate at the base; the mesal margins diverge slightly; distal margin serrate; meso-distal angle rounded and produced into a lobule. The second lobe is very small, being simply an angular projection of the body wall. The third lobe is about three times as wide as the second lobe, but it projects only a little beyond the margin of the segment.

The *plates* are simple and spine-like. There are two minute ones between mesal lobes; two between first and second lobes; two or three between second and third lobes; a group of three or four larger ones laterad of third lobe; and another group of four or five still larger ones about midway between this group and the penultimate segment. Each of the three segments preceding the last bears on each lateral margin about seven plates.

Two *spines* accompany each group of plates, one on the dorsal surface and one on the ventral. The first and second spines of each side are very small; the third, which is between the second and third lobes, is the largest; the fourth and fifth are successively smaller.

There are two conspicuous *club-shaped organs*, which appear like thickenings of the body wall, but which are really within the body cephalad of the mesal lobes. These organs are about three times as long as the mesal lobes; they converge caudad; and the cephalic end of each is suddenly enlarged. This species may be distinguished from any other known American coccid by the presence of these organs.

THE ORANGE CHIONASPIS

75. Chionaspis citri n. sp. (Fig. 13).

Chionaspis euonymi Comstock (in part), Agr. Rept. 1880, p. 313.

In the Report of the Department of Agriculture for 1880 I described a species of Chionaspis which differed from all other spe-

cies of that genus known at that time by the color of the scale of the female, which is black. This species was found on *Euonymus latifolia* at Norfolk, Va. I stated in my account of this insect that it occurred also on orange trees in Louisiana and Cuba. A re-examination of the specimens on orange has convinced me that they are specifically distinct from those on euonymus. I therefore propose for that form the specific name of *citri*. The species can be recognized by the following characters:

Scale of female.— The scale of the female is of a dirty blackish brown color with a gray margin; the exuviae are brownish yellow. There is a central ridge from which the sides of the scale slope like the roof of a house. The greater prominence of this ridge and the more elongated form of the scale are the principal differences between this scale and that of the female of *Ch. euonymi.* There is no danger of its being mistaken for any other known species.

Female.— The last segment of the female presents the following characters:

FIG. 13 (Fig. 105, Cornell series)

The groups of *spinnerets* are wanting. In two specimens, however, I have seen a single compound spinneret in place of the mesal and cephalo-lateral groups. A number of simple spinnerets are located as shown in the figure. Upon the disk of each of those near the margin of the segment was observed a delicate short spine.

The mesal *lobes* are conspicuous, diverge distad, and are serrate. They are larger and more distinctly serrate than in *Ch. euonymi.* The second and third lobes are deeply incised, and more or less serrate. In each case the mesal lobule is larger than the lateral one.

There is one *plate* laterad of each lobe, one midway between third lobe and the penultimate segment, and one near the penultimate segment. This segment and the antepenult bear on each side five or six plate-like spinnerets.

On the dorsal surface, the *spines* are as follows: One laterad first lobe; one between the lobules of the second and third lobes respectively; one a little more than halfway from the third to the fourth plate; and one similarly situated between the fourth and fifth plates. There is usually a notch or incision in the margin of the segment near which the fourth and fifth spines are situated. On the ventral surface, the first spine is obsolete or wanting; the second and third are laterad of the lateral lobule of the second and third lobes respectively; the fourth and fifth are just mesad of the base of the fourth and fifth plates respectively. There are also one or two spines among the plates on the penultimate and antepenultimate segments.

This species may readily be distinguished from *Ch. euonymi* by the following characters: there are no groups of spinnerets; the mesal lobes are larger and more distinctly serrate than in *Ch. euonymi*; and in the last-named species the plates are in twos, while in *Ch. citri* they occur singly.

THE CHIONASPIS OF EUONYMUS

76. Chionaspis euonymi Comstock.

This is a very destructive enemy of *Euonymus latifolia* at Norfolk, Va. For description and figures, see Agr. Report 1880, page 313. I know of no other food plant of this species than euonymus, the supposed specimens of this species on orange having proved specifically distinct. (See *Chionaspis citri*, above.)

THE SCURFY BARK LOUSE

77. Chionaspis furfurus (Fitch).

"Approaches *Coccus cryptogamus* Dalman." Harris, Insects injurious to vegetation, 1841, p. 203 (Flint ed., p. 254).
Aspidiotus furfurus Fitch, Report N. Y. State Agr. Soc., 1856, p. 352.
Aspidiotus cerasi Fitch, Report N. Y. State Agr. Soc., 1856, p. 368.
Coccus Harrisii Walsh, Prairie Farmer, May 1860.
Aspidiotus Harrisii Walsh. Signoret, Essai, 1876, p. 604.
Chionaspis furfurus (Fitch) Comstock, Report 1880, p. 315.

This is the common white scale of pear and apple. It also infests the different species of cherry, and has been found on the European mountain ash (*Sorbus aucuparia*) in this country. For description and figures, see Agr. Report 1880, page 315.

LINTNER'S SCALE INSECT

78. Chionaspis lintneri n. sp. (Fig. 14).

I have received from the State Entomologist of New York a species of Chionaspis which infests a species of alder, *Viburnum lantanoides,* and a third unknown plant.

Scales.— The scales of this species so closely resemble those of *Chionaspis salicis* that I have been unable to detect any constant difference. That of the female is white, sometimes slightly brownish, much widened near the caudal end, and with the exuviae naked; that of the male is white and tricarinated.

Female.— The color of the body in old dry specimens is reddish brown with the last segment yellow. In living specimens it is probably as with *C. salicis,* reddish.

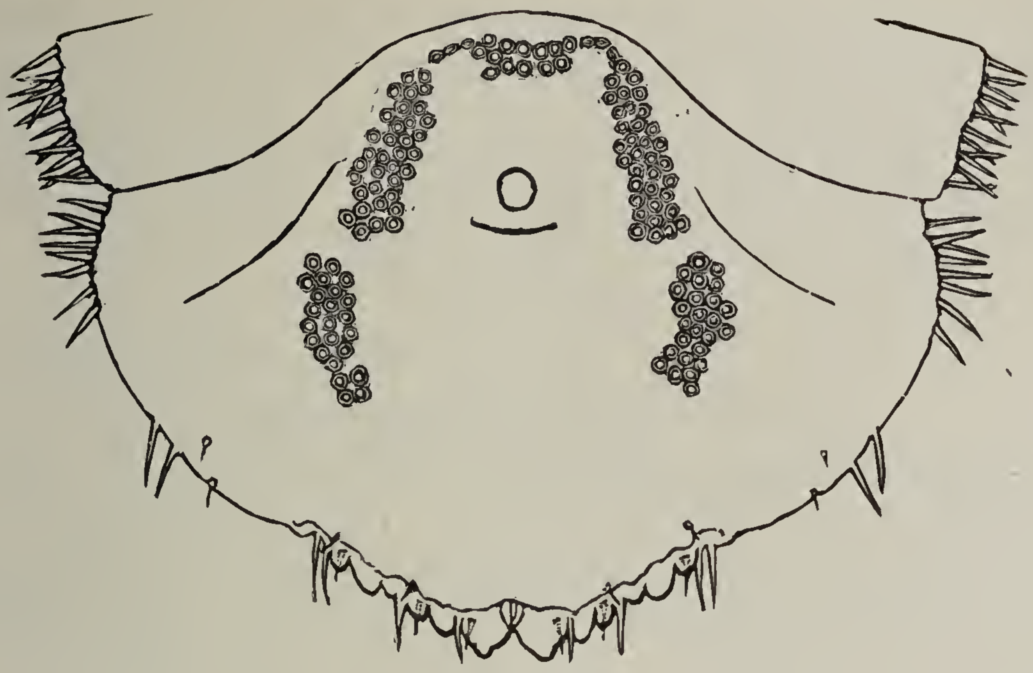

FIG. 14 (Fig. 106, Cornell series)

There are five *groups of spinnerets* (Fig. 14): the mesal consists of eleven to seventeen, the cephalo-laterals each of thirty to forty, usually thirty-five, and the caudo-laterals of about twenty-five. The mesal and cephalo-lateral groups are confluent, being joined by two or three rather elongated spinnerets.

There are three pairs of well-developed *lobes*; the distal ends of the mesal lobes are pointed or obscurely trilobed; the second and third lobes are deeply incised; the mesal lobule is in each case much the larger; the distal margin of each lobule is simply rounded.

There is one *plate* laterad of each of the mesal and second lobes; usually two laterad of each third lobe, but sometimes only one; and two plates about halfway between each third lobe and the penultimate segment. The penultimate segment bears on each side six to nine plates, and the antepenultimate about twelve; there are also a few of these plates cephalad of this segment.

On the dorsal surface there is a *spine* on the lateral part of each lobe, and one a short distance mesad of the fifth plate. The ventral spines are much smaller, and in each case with the exception of the first, which is wanting, are situated a short distance laterad of those on the dorsal surface.

THE SOUR-GUM SCALE

79. **Chionaspis nyssae** Comstock.

This is a species found upon the black, or sour, gum (*Nyssa multiflora*), in North Carolina. For description and figure, see Agr. Report 1880, page 316.

THE CALIFORNIA WILLOW SCALE

80. **Chionaspis ortholobis** Comstock.

I found this species upon willow in southern California. It differs from all other known species of this genus in that the scale of the male is not carinated. For description and figures, see Agr. Report 1880, page 317.

THE PINE-LEAF SCALE INSECT

81. **Chionaspis pinifolii** (Fitch).

Aspidiotus pinifoliae Fitch, Report N. Y. State Agr. Soc., 1855, p. 488.
Mytilaspis pinifolii (Fitch) LeBaron, First Report State Entomologist of Illinois, p. 83.
Chionaspis pinifoliae (Fitch) Comstock, Report 1880, p. 318.

This is the common white scale of pine and spruce; it occurs throughout the United States. For description and figures, see Agr. Report 1880, page 318.

The color of the eggs of this species is purplish brown, covered slightly with a whitish powder.

Natural enemies.— This species is preyed upon by the chalcid parasite *Aphelinus mytilaspidis* LeBaron, which is described in Agr. Report 1880, p. 354.

THE CHIONASPIS OF OAK

82. **Chionaspis quercus** Comstock.

This is an interesting species which I found on white oak (*Quercus lobata*), in the San Fernando Valley, California. It differs from all Diaspinae known to me in that the caudal end of the body of

the female is terminated by a single mesal lobe. For description and figures, see Agr. Report 1880, page 319. Add to this description Plate XI, figure 8, scale of female.

THE WILLOW SCALE

83. Chionaspis salicis (Linn.).

Coccus salicis Linn., Syst. Nat., 741. 15.
Chionaspis salicis Signoret, Essai, 1869, p. 447.
Chionaspis fraxini Signoret, Essai, 1869, p. 445.
Aspidiotus salicis-nigrae Walsh, Report Acting State Entomologist of Illinois (1868), p. 40.
Mytilaspis salicis LeBaron, Second Report State Entomologist of Illinois (1872), p. 140.

This is the common white scale of willow and ash in Europe and in this country. For description and figures, see Agr. Report 1880, page 320; Plate XVI, figure 5, margin of last segment of female. Compare this figure with figure 6 of the same plate, which represents the margin of the last segment of *Ch. ortholobis*. The important character is the *direction* of the mesal lobes. The number of the plates on the lateral margin of the segment varies in each species. The most conspicuous difference between these two species is presented by the scale of the male, which is tricarinated in *Ch. salicis* and has no carinae in *Ch. ortholobis*.

THE SALT-MARSH-GRASS SCALE

84. Chionaspis spartinae n. sp. (Plate III, figs. 3 and 3*a*).

This species is especially interesting on account of its habitat. It was collected by Mr. William Trelease on salt marsh grass (*Spartina stricta*), at Woods Holl, Mass. The insects were on plants growing so that at high tide they were commonly submerged in pure salt water nearly up to the insects, which when collected were drenched with salt spray. The insects occurred in great numbers on the pieces of grass which I received, the inner surface of the leaves being completely covered so that the scales overlapped. None were observed on the outer surface of the leaves. All the scales were so situated that the cephalic end was uppermost.

Scale of female.— The scale of the female is snowy white, with the exuviae bright yellow. The second skin, however, is more or less covered with the white excretion. The scales are long, narrow, and curved, resembling those of Mytilaspis in form, but differing from that genus in color.

Female.— The color of the full-grown female before oviposition is as follows: head and cephalic part of second segment lemon-yellow; caudal part of second segment, third, and fourth segments purplish red; fifth, sixth, and seventh segments lemon-yellow with central line of purple; last segment light orange-yellow. The purplish red of the body was due apparently to the color of the contained eggs. The last segment presents the following characters (Plate III, figs. 3 and 3*a*):

The mesal group of *spinnerets* consists of fifteen to twenty, the cephalo-laterals of thirty to forty, the caudo-laterals of twenty-five to thirty.

The mesal *lobes* are small, acutely triangular, and diverging; the second lobes are inconspicuous and incised; the third lobes are rudimentary.

There are two *plates* laterad of each lobe, and two near the penultimate segment. The mesal member of each pair of plates is the smaller, and is sometimes concealed by the lateral plate; so that there appears to be but one where there are two.

On the ventral surface there is a *spine* near the base of each group of plates; on the dorsal surface there is a spine a short distance mesad of each of the ventral spines, spines one, two, and three being on the corresponding lobes. On the ventral surface there is a second row of spines a short distance from the caudal margin of the segment (Fig. —).

Scale of male.— The scale of the male is snowy white, with the larval skin bright yellow; it is tricarinate or unicarinate, the lateral carinae being feeble or wanting.

SPECIES OF CHIONASPIS NOT YET OBSERVED IN THE UNITED STATES

85. Chionaspis aceris Signoret.

Chionaspis aceris Signoret, Essai, 1869, p. 442.

A species of Chionaspis which infests maple in Europe is de-

scribed by Signoret under the name of *C. aceris*. The scale of the female resembles that of *C. salicis*. The scale of the male presents a feeble carina on the middle line; the extremity is rounded and flat. The last segment of the female presents a single pair of lobes, and on each side five or six plates. The penultimate segment bears six or seven plates on each side, and the antepenult three. The cephalic border of the head, which is slightly concave, presents two little hairs, and, near the border, two little irregular protuberances which Signoret believed to be vestiges of antennae.

86. Chionaspis alni Signoret.

Chionaspis alni Signoret, Essai, 1869, p. 443.

This is a species collected by Signoret on the bark of alder in Switzerland. The scale of the female is of the typical form, white, with the exuviae reddish brown. The female is long with the abdominal segmentation very pronounced, the color is yellow a little reddish; the mesal group of spinnerets consists of twelve to fifteen, the cephalo-laterals of seventeen to eighteen, and the caudo-laterals of fifteen to sixteen. The scale of the male resembles that of *Ch. salicis*.

87. Chionaspis aspidistrae Signoret.

Chionaspis aspidistrae Signoret, Essai, 1869, p. 443.

This is a species which infests a Chinese liliaceous plant belonging to the genus Aspidistra, a plant used as an ornamental house plant. The scale of the female forms a thin pellicle; it is of the typical form, but is remarkable on account of the large size of the second skin, which with the first occupies about one-third of the length of the scale. The female as described by Signoret is also quite remarkable. The body is yellow, much elongated, with the abdominal segmentation very distinct, the segments being prolonged laterally into prominent lobes; the last segment bears a single pair of lobes, which are trilobed (*trifolies*); the mesal group of spinnerets of eight to nine, the cephalo-laterals of eighteen to twenty-four, and the caudo-laterals of fifteen to eighteen. The lateral groups of spinnerets are sometimes nearly continuous. The scale of the male is tricarinated; the larval skin occupies hardly

one-fifth of the length of the scale, which is four times longer than wide. The male is grayish white, more or less rosy, the color is a little deeper on the head and the middle of the prothorax. The mesothorax is very long so that the first pair of legs are widely separated from the second. The wings are long.

88. Chionaspis braziliensis Signoret.

Chionaspis braziliensis Signoret, Essai, 1869, p. 444.

This species was described from specimens collected at Bahia, Brazil. The food plant is a shrub the name of which is not given. The scale of the female is yellowish white with the exuviae brownish yellow. The mesal lobes of the last segment of the female are hardly visible; the mesal group of spinnerets consists of eight, the cephalo-laterals of fourteen to fifteen, and the caudo-laterals of fifteen to sixteen. The scale of the male is white and carinated.

89. Chionaspis planchonii Signoret.

Chionaspis planchonii Signoret, Essai, 1869, p. 446.

This species infests oak (*Quercus ilex*) in southern Europe. The scale of the female is white with the exuviae clear yellow. The body of the female is yellow; the mesal group of pores consists of fifteen, the cephalo-laterals of at least thirty-five, and the caudo-laterals of fifteen. The mesal and cephalo-lateral groups are nearly continuous. The scale of the male resembles that of *Ch. salicis,* but it is twice as large. The branches upon which the female scales exist present a very light excretion resembling mould. A similar character is presented by *Ch. populi* and *Diaspis boisduvalii.* The last-named species is the only one of the three which I have met, and in that this excretion is produced by the males.

90. Chionaspis populi (Bärensp.).

Aspidiotus populi Bärensprung, Zeit. für Zool., Zoot., Alton et Burm (1849), 167.
Chionaspis populi Signoret, Essai, 1869, p. 446.

The species of Chionaspis which infests poplar in Europe has been named *Ch. populi,* but the descriptions of the species are very imperfect. The species is said to be closely allied to *Ch. salicis,* but to differ from that species as follows: in *Ch. populi* the male is yellow, and the scales are accompanied by an excretion

resembling mould; in *Ch. salicis* the male is red, and the mould-like excretion is absent.

91. Chionaspis vaccinii (Bouché).

Aspidiotus vaccinii Bouché, Ent. Zeit. Stett., XII, 111.
Diaspis niveus Bremi, Coll., Mayr (Signoret).
Chionaspis vaccinii Signoret, Essai, 1869, p. 448.

This is a species which infests a species of cranberry (*Vaccinium myrtillus*) in the forests of Switzerland. It is said to resemble *Ch. salicis*. The scale is white with the exuviae brownish red. The female is long, narrow towards the head, and widest at the penultimate segment. The mesal group of pores consists of fifteen to seventeen, the cephalo-laterals of eighteen to twenty, and the caudo-laterals of twenty to twenty-five. The mesal lobes are well developed, and on each side there are two smaller lobes. The scale of the male is long, carinated, and snowy white.

Genus **UHLERIA** Comstock

This genus includes species of Diaspinae in which upon the scale of the female only one larval skin is visible at the cephalic extremity; the second skin is present, but it is entirely covered by secretion. This skin is large, covering the insect entirely. The scale is narrow at its cephalic end; it soon widens, and the sides are parallel throughout the greater part of its length. The three cephalic groups of spinnerets are united, forming a continuous line.

This is the genus Fiorinia of Targioni-Tozzetti. It was established by that author to receive the species described by him under the name *Diaspis fioriniae*. This author at the same time changed the specific name of the species to *pellucida*. According to the rules of nomenclature now generally adopted by zoologists, the original specific name must be restored and a new generic name given.

It gives me great pleasure to name this genus in honor of our highest authority on the order of insects to which it belongs. And I wish here to acknowledge the encouragement and material aid in my studies of the Coccidae which he has so generously given me.

THE UHLERIA OF CAMELLIA

92. Uhleria camelliae Comstock (Plate II, fig. 9).

Fiorinia camelliae Comstock, Agr. Report 1880, 329.

This is a very troublesome pest of the camellia in the conservatories of the U. S. Department of Agriculture. It also infests a palm (*Kentia balmoriana*) and *Cycas revoluta.* For description and figures, see (under name of *Fiorinia camelliae*) Agr. Report 1880, page 329.

SPECIES OF UHLERIA NOT YET OBSERVED IN THE UNITED STATES

93. Uhleria fioriniae (Targ.-Tozz.).

Diaspis fioriniae Targ.-Tozz. (1867), Studi sulle Cocciniglie, 14.
Fiorinia pellucida Targ.-Tozz., Catal. (1868), 42.
Chermes arecae Boisduval, Insect. Agric. (1868).

This species is said to be common on many plants in hothouses in Europe, and especially upon *Areca aurea* and *Phytelephas macrocarpa.* As yet I have not met this species but I presume it will be found in this country on hothouse plants.

According to Signoret (Essai, 1869, 449), this species is characterized as follows: The scale of the female is thin, of a transparent brownish yellow with the base a little darker. The sides are almost parallel. There is but little secretion outside of the second skin of which the scale is formed. The female is grayish yellow, three times longer than wide, and bears on the lateral margin of each segment a spine and on the penultimate segment two or three. The last segment bears a curved line of spinnerets, fifteen in number according to the plate, and two groups, the caudolaterals, of five to six each. The scale of the male is of the same nature and form as that of the female, only it is smaller and narrower.

94. Uhleria gigas (Maskell).

Diaspis gigas Maskell, Trans. and Proc. New Zealand Institute, XI, 201.
Fiorinia asteliae Maskell, l. c., XII, 292.

This is a New Zeland species which infests *Atherosperma novaezealandiae.* The scale of the female is sometimes more than one-

eighth inch long and one-sixteenth inch wide. The female is one-twelfth inch in length. The scale is yellowish brown or dirty white, flat, roughly pear-shaped, thin in texture. The first skin occupies the broad end, the second nearly the entire scale. According to Maskell's figure there are about sixty spinnerets arranged in an arc cephalad of the vaginal opening.

Genus **PARLATORIA** Targioni-Tozzetti

Scale of the female either circular or elongated, with the exuviae at the cephalic margin or end. Scale of male elongated, with the sides nearly parallel, and the exuviae at the cephalic end. The mesal part of the scale of the male is not carinated and is seldom higher than the sides; usually, and especially with old scales after the adult has emerged, the mesal part is depressed, giving that part of the scale caudad of the larval skin the form of a gutter.

The margin of the last segment of the female is crenulated, and fringed with toothed scale-like plates. (See Agr. Report 1880, Pl. XIX, fig. 3, and Plate XX, fig. 5, also Plate IV of this report.)

In this genus the form of the scale of the female varies greatly. (See Plate II, figs. 6, 7, and 8.) The only generic character presented by the scale of this sex is the large size of the second skin. The form of the scale of the male is, however, quite constant. But the most important generic character is the structure of the margin of the last segment of the female.

There is but little variation in the structure of the margin of this segment in the three or four species of Parlatoria which are known (see Plate IV). There are only four groups of spinnerets, each usually consisting of eight or nine; but the number in each group varies from four to ten. There are three pairs of well-developed lobes; each lobe is widest near the middle, tapering cephalad, and suddenly narrowed caudad. Except in *P. proteus* (Plate IV, fig. 3), there is a fourth rudimentary lobe upon each side about midway between the third lobe and the penultimate segment; this is represented at *a* in the figures of Plate IV. In *P. pergandii* (Plate IV, fig. 2), and var. *camelliae* (Plate IV, fig. 4), there is a similar lobe on the penultimate segment, cephalad of the caudal plate of

that segment. Connecting the bases of the lobes in all the species are crescent-shaped thickenings of the body wall, which are in reality the thickened margins of elongated pores placed at right angles to the median line of the body. In each species there are two plates between the mesal lobes; two between first and second lobes; and three between second and third lobes. These are similar in shape, and in each case extend caudad as far as the tips of the lobes. Each plate is oblong, with the sides parallel and with the distal extremity fringed. Between the third and fourth lobes are three plates varying in shape from the form just described to palmate. The plates on this segment cephalad of the fourth lobe are usually palmate. The three segments preceding the last bear from five to ten plates each, on each lateral margin. The shapes of these plates afford specific characters. Each lobe bears a spine on its dorsal surface near the lateral margin at its base. The spines of the ventral surface (except the first, which is obsolete), are longer and more conspicuous; the second, third, and fourth are each situated cephalad of the lateral margin of the first plate laterad of the second, third, and fourth lobes respectively. Each of the three segments preceding the last bears a conspicuous spine near the middle of each lateral margin.

The species can be readily distinguished as follows:

A. Scale of female circular. **pergandii.**

AA. Scale of female elongated.

B. Scale black. **zizyphi.**

BB. Scale brownish yellow. **proteus.**

95. Parlatoria pergandii Comstock (Plate II, figs. 6 and 6*a*; Plate IV, fig. 2).

Parlatoria pergandii Comstock, Agr. Report 1880, p. 327.

This species infests the trunk, leaves, and fruit of citrus trees in Florida. See Agr. Report 1880, page 327; Plate XI, fig. 4*a*, scale of female, 4*b*, scale of male; Plate XXI, fig. 8, male; Plate XIX, fig. 3, last segment of female; Plate XX, fig. 5, margin of the same.

Natural enemies.— I have bred from this species the parasitic chalcis fly *Aphelinus fuscipennis* Howard, which is described in my report for 1880, page 356.

Parlatoria pergandii *var.* **camelliae** (Plate IV, fig. 4).

Upon the leaves of camellia growing in the conservatory of the Department of Agriculture were found a few specimens of a species of Parlatoria which is either *P. pergandii* or a distinct species very closely allied to it. I am inclined to the latter view, but am unwilling to decide until I have seen more specimens. The form on camellia differs from that on orange as follows: The scale of the female widens suddenly near the middle of the second skin; thus one-half of the exuviae project beyond the part of the scale composed of excretion. In *P. pergandii,* although the exuviae are marginal, they rarely project beyond the margin. The fourth and fifth lobes of the margin of the last segment of the female (Plate IV, fig. 4, *a* and *b*) taper to a point. In *P. pergandii* they are more or less rounded and each is terminated by a papilla. In var. *camelliae* the plates laterad of the fifth lobe are fringed more than the corresponding plates in *P. pergandii.* Described from three females.

96. **Parlatoria proteus** (Curtis) (Plate II, figs. 7 and 7*a*; Plate IV, fig. 3).

Aspidiotus proteus Ruricola (Curtis), Gardeners' Chronicle, 1843, p. 676.
Parlatoria orbicularis Targ.-Tozz., Catal. (1868), 42.
Parlatoria proteus Curtis. Signoret, Essai, 1869, p. 450.

This is a species which as yet I have found only in a single locality in this country, and in small numbers. It infests the leaves of a species of Microsamia growing in the conservatory of the Department of Agriculture. Although careful search was made, we were unable to detect its presence on any other plant. It probably occurs, however, in other conservatories in the United States, and upon other plants, as it is well known in Europe, where it infests several species of plants but especially Selenipedium and Vanda. Through the kindness of M. Signoret I have received specimens from Europe, and have thus been able to prove the specific identity of our species.

The scale of the female (Plate II, fig. 7) is elongate, more or less oval, of a transparent brownish yellow color, and whitish toward the border. The exuviae are rounded oval in form; in

length they are equal to about three-sevenths of the length of the fully formed scale.

For a description of the last segment of the female see the generic characters given above. This species is peculiar in wanting the fourth lobe; in place of this lobe there is a small fringed plate (Plate IV, fig. 3*a*). The plates on the three segments preceding the last are more irregular in form than in other species of this genus (Plate IV, fig. 3).

The scale of the male (Plate II, fig. 7*a*) is light brown with the exuviae black.

97. **Parlatoria zizyphi** (Lucas) (Plate II, fig. 8; Plate IV, fig. 1).

Coccus ziziphus Lucas (1853), Ann. Soc. Ent. Fr., Bull. XXVIII.
Kermes aurantii Boisd. (1867), Ent. Hort., 338.
Parlatoria Lucasii Targ.-Tozz., Catal. (1868), 42.
Parlatoria zizyphi (Lucas) Signoret, Essai, 1869, p. 451.

This is a species which infests oranges in Europe and is occasionally found on imported oranges in our markets. It is readily recognized by the form and color of the scale of the female (Plate II, fig. 8).

The scale of the female is long and very black. This color is due to the color of the exuviae which are so large that they cover nearly the whole scale as shown in the figure. The first skin is oval and of medium size; the second skin is quadrangular, elongate, and very large. On the middle line there is usually a longitudinal depression in the center of which there is a ridge. That part of the scale which extends beyond the caudal end of the second skin is brownish white.

The fourth lobe of the last segment of the female is as long as the other lobes and tapers evenly to a point. The plates on the margins of the three segments preceding the last are as long as any of the lobes, are crowded together, and are irregularly incised (Plate IV, fig. 1).

The scale of the male is of the form characteristic of the genus. It is dirty white with the larval skin black.

Genus **MYTILASPIS** Targ.-Tozz.

This genus includes the species of Diaspinae in which the scale is long, narrow, more or less curved, and with the exuviae at the cephalic extremity. The scale of the male resembles that of the female in form, but it can be readily distinguished by its small size and by bearing only one larval skin.

In all the species of Mytilaspis which I have studied the caudal part (about one-fourth) of the scale of the male is joined to the remainder by a thin portion which serves as a hinge, allowing the posterior part to be lifted when the male emerges.

There is little danger of species of Mytilaspis being placed in any other genus; but members of other genera are liable to be mistaken for Mytilaspis. See Chionaspis, Fiorinia, and Parlatoria.

I believe that the recognizing of different species of the Coccidae has been in many cases more a matter of feeling than of knowledge; and this has been the case especially in the genus Mytilaspis. There is no doubt that new names have been given to forms simply because they looked a little different from other forms, or because they occurred on a different plant. To my mind it is evident that the characters by which the closely allied species of this genus can be distinguished have not been worked out. And until they are determined I cannot see what is to be gained by giving a name to every form which seems to be a little different from other forms, or which infests a plant different from those infested by the other forms.

According to the plan adopted by a large proportion of the writers who have described Coccidae, I have before me nearly forty American "species" of the genus Mytilaspis. But excepting *M. pandani,* which is placed in this genus only provisionally, I am able to distinguish but three American species. And it is even quite difficult to state definitely the differences between two of these. The following statement will serve the purposes of an analytical table:

M. pandani may be recognized at once by the large size of the exuviae.

M. gloverii differs from the other American forms by its very narrow scale within which the eggs are deposited in two regular rows.

There remain of the recognized American species only *M. citricola* and *M. pomorum.* The former has been found only on citrus plants; the latter, although it infests very many plants, has not been found on any belonging to the genus Citrus. This, however, is not given as a character, but simply an interesting fact. The mesal group of spinnerets are almost invariably arranged in a single row in *M. citricola*; in *M. pomorum* they are massed, and are greater in number. The mesal lobes in *M. citricola* are only two-thirds as wide as in *M. pomorum.* The distal end of each mesal lobe in *M. citricola* bears many notches; in *M. pomorum* it is nearly entire.

THE ORANGE SCALE

98. Mytilaspis citricola (Packard).

Aspidiotus citricola Packard, Guide to the study of insects, second edition, (1870), 527.
Mytilaspis citricola (Packard), Comstock, U. S. Agr. Report 1880, 321.

This is one of the two most common species of scale insects found on citrus trees in Florida. It is probably an European species, as I have frequently found it on imported oranges in our market. It also occurs in Louisiana. For description and figures, see Agr. Report 1880, page 321. Compare with *M. gloverii.*

From this species I have bred the chalcid parasite *Aphycus flavus* Howard, described in Agr. Report 1880, page 365.

GLOVER'S SCALE

99. Mytilaspis gloverii (Packard).

Coccus gloverii Packard, Guide to the study of insects (1869), p. 527.
Aspidiotus gloverii Packard, ibid., second edition (1870), p. 527.
Mytilaspis gloverii (Packard). Ashmead, Orange insects, 1880, p. 1.

This is a very common species on citrus trees in Florida and Louisiana. It infests the fruit, leaves, and bark of the trees, and is usually associated with *M. citricola.* For description and figures, see Agr. Report 1880, page 323. Compare with *M. citricola.*

THE PANDANNIS SCALE

100. Mytilaspis pandani Comstock.

This species, which I have referred provisionally to Mytilaspis, occurs upon pandanus in the Harvard Botanic Garden at Cambridge, Mass. For description and figures, see Agr. Report 1880, page 324.

THE OYSTER-SHELL BARK LOUSE OF THE APPLE

101. Mytilaspis pomorum (Bouché) (Plate II, figs. 5 and 5*a*).

Aspidiotus pomorum Bouché, Ent. Zeit. Stett. (1851), XII, no. 1

Aspidiotus conchiformis of authors; but not *A. conchiformis* Gmelin, Syst. Nat., 2221.

Aspidiotus pyrus-malus Bob. Kennicott (1854), Acad. Science of Cleveland.

Aspidiotus juglandis Fitch, Annual Report N. Y. State Agr. Soc., 1856, 163. (Not the species described under this name by Signoret, Essai, 1870, 95.)

Mytilaspis pomicorticis Riley, Fifth Report State Entomologist, Missouri, p. 95.

Mytilaspis pomorum (Bouché). Signoret, Essai, 1870, p. 98.

This is the most widely spread and best-known scale insect infesting apple. In certain parts of California its ravages are overshadowed by the greater injuries of the pernicious scale insect (*Aspidiotus perniciosus*), but even there the oyster-shell bark louse of the apple is a formidable and well-known pest.

For description, list of food plants, and figure, see Agr. Report 1880, page 325.

From this species I have bred the following-named chalcid parasites, all of which are described in the report just cited: *Aphelinus mytilaspidis* LeBaron, *Aphelinus abnormus* Howard, *Aphelinus fuscipennis* Howard, and *Anaphes gracilis* Howard.

It is very unfortunate that the oyster-shell bark louse of the apple has been known at different intervals by widely different names. This is especially to be regretted as the species is one that interests a very large number of people who cannot be expected to keep track of the changes in scientific nomenclature. But without a knowledge of these changes it is impossible for one to avail himself of what has been published in the various books and

agricultural journals on this subject; for the reader will be sure to think that the different articles are concerning very different insects. I will therefore give a brief sketch of the changes which have occurred.

In 1738 Reaumur * first called attention to the group of insects to which the oyster-shell bark louse of the apple belongs. On plate five of the fourth of his Memoires he figures a bark louse upon elm which is undoubtedly a Mytilaspis; and he proposes for this genus, which was then described for the first time, the name *Coccids in the form of a shell (Des gallinsectes en forme de coquille).*

In 1762 the species of Mytilaspis which infests elm was named *Coccus arborum linearis* by Etienne Louis Geoffroy.†

In 1788 this species was named *Coccus conchiformis* by Gmelin in his edition (ed. XIII) of the Systema Naturae of Linnaeus. *Conchiformis* being the first specific name proposed for this species in accordance with the rules of nomenclature now in use, is the one adopted for it.

In 1833 Bouché‡ established the genus Aspidiotus for those species of Coccidae which live under a scale. Accordingly the scientific name of the oyster-shell bark louse of the elm, as we may call it, became *Aspidiotus conchiformis.*

In 1843 Curtis, writing over the pseudonym of *Ruricola* in the Gardeners' Chronicle (pages 735–736), gave a description and figures of "the apple-tree mussel scale," or "dry scale." This is doubtless the same insect as that which is known in this country as the oyster-shell bark louse of the apple. Curtis considered this insect as identical with that which infests the elm and which has been described by Gmelin under the specific name of *conchiformis.* He therefore applied the name *Aspidiotus conchiformis* to this pest of the apple.

Twelve years later Dr. Fitch,§ the first State Entomologist of New York, gave a description of "the apple bark louse" and, following Curtis, applied the name *Aspidiotus conchiformis* to it, and this name has been applied to this pest of the apple by the

* Memoires pour servir a l'histoire des insectes, Tome IV, 69.

† Histoire abrégée des insectes.

‡ Naturgeschichte der garten insekten, 52.

§ Trans. N. Y. State Agr. Soc., XIII, 735.

majority of writers on economic entomology from the time of Curtis to the present day. It is, therefore, under this name that the student must look for information concerning this pest in most of the standard works on economic entomology.

Unfortunately Curtis and those who followed him overlooked the fact that Bouché had described* the bark louse of the apple as a distinct species from that infesting the elm and had given to it the name of *Aspidiotus pomorum*; by which name it should have been designated by Curtis.

But the progress of science has rendered another change necessary. It is found that the genus Aspidiotus of Bouché includes several genera. Therefore the name Aspidiotus has been restricted to one of these genera, and the name Mytilaspis given to the genus to which the oyster-shell bark louse of the apple belongs. The name, then, of this pest is *Mytilaspis pomorum.*

The matter has been further complicated by the proposal in this country of several other names for what is doubtless this species. These names are given in the table of synonyms above. I will discuss here only one of them, as no writer has persisted in the use of the others.

Professor Riley in his Fifth Missouri Report proposed the name *M. pomicorticis* for this species on the ground that according to the description of Bouché *M. pomorum* has red eggs, while the eggs of this species are white. It is evident, however, that there is a mistake in the description of Bouché; for there is no species of Mytilaspis known in which the eggs are normally red. If no other mistakes of this kind had been made, we might hesitate before pronouncing this to be one; but Bouché in describing *M. pinnaeformis* says that the eggs of this species are also a deep red; while Signoret states that they are white tinged with yellow. Signoret quotes the statement of Bouché as to the color of the eggs and adds, "That depends on the age of the eggs." An American writer† in describing *M. gloverii* states that the eggs are a bright red, notwithstanding that his residence is surrounded with orange trees, upon which may be found at the proper season thou-

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* Ent. Zeitung Stett., 1851.

† Ashmead, Orange insects, p. 4.

sands of scales of this species each covering white eggs. The fact is, as my observations on this particular species (*M. gloverii*) show, the eggs which are white when first laid become tinged with purple before hatching. There can be no reasonable doubt that the species described by Bouché as *M. pomorum* is the common Mytilaspis of the apple of Europe. And as the most careful study has failed to detect any difference between that form and the one which infests apple trees in this country, our species should be known by the same name. The suggestion made by Mr. Riley* that, in case Bouché's description does refer to our species, it "is so false in one of the most important characters that it is valueless and should be ignored," cannot be seriously entertained. Nothing could quicker bring confusion into our nomenclature than the adoption of the doctrine that a misstatement in a specific description should render the description void.

SPECIES OF MYTILASPIS NOT YET OBSERVED IN THE UNITED STATES

102. Mytilaspis abietis (Schrank).

Coccus abietis Sch., Beit. zur Naturg. (1776), 48.
C. arborum Sch., Enum. Ins. Aust. (1781), 295.
C. pineti Sch., Fauna Boica (1801), 146.
Mytilaspis abietis (Sch.) Signoret, Essai, 1870, 92.

This species infests the branches of fir or spruce (Abies) in Europe. Scale of female long, straight or more or less curved and grayish brown in color. Female of a grayish brown, broad towards the caudal end and narrow towards the head. Five groups of spinnerets: the mesal consist of fifteen to seventeen, the cephalo-laterals each of twenty, and the caudo-laterals of ten to twelve.

103. Mytilaspis (?) buxi (Bouché).

Aspidiotus buxi Bouché, Ent. Zeit. Stett., XII, 110.
Mytilaspis? buxi (Bouché) Signoret, Essai, 1870, 93.

This species is found on the leaves of box (*Buxus sempervirens*)

*American Naturalist, 1874, 168.

in Europe. It is remarkable for the large size of the exuviae, the second skin reaching the middle of the scale; the form of the scale is an elongated oval. The last segment of the female bears five groups of spinnerets: the mesal consists of eight to nine, the cephalo-laterals each fourteen to fifteen, and the caudo-laterals of ten to eleven. There are two pairs of lobes; the mesal lobes are each trilobed. Scale of male small, deep yellow, and with the sides parallel. Male elongated, yellow with the thoracic band brown.

104. Mytilaspis conchiformis (Gmelin).

Ch. conchiformis Gmelin (1788), Syst. Nat., 2221.
Asp. conchiformis Curtis, Gard. Chron. (1843), 735.
Diaspis linearis Costa, Faun. Regn. Nap. (1837) Gall. Ins. 21. 3.
Mytilaspis linearis Targ.-Tozz., Catal. (1869), 45. 1.
Mytilaspis conchiformis (Gmelin) Signoret, Essai, 1870, 93.

This is the species found on elm in Europe. The scale resembles that of *M. pomorum*. The female has five groups of spinnerets. The mesal group consists of six to seven, the cephalo-laterals each of eight to nine, the caudo-laterals of five to six.

105. Mytilaspis cordylinidis Maskell.

Mytilaspis cordylnidis Maskell, Trans. and Proc. New Zealand Institute, XI, 195.

This is a New Zealand species which infests a large number of plants in that country, of which the following are enumerated by Maskell: Cordyline, Asplenium, Phormium, Gahnia, Drimys, Astelia, and Eucalyptus.

The scale is very long and narrow, generally straight, sometimes curved, semi-cylindrical. Length about one-eighth inch; breadth one-thirtieth inch. Color pure white except the exuviae, which are bright yellow. The exuviae occupy rather more than one-fourth the length of the scale. The eggs are of a bright yellow color. The adult female is pale golden, about three times as long as broad. There are five groups of spinnerets. The mesal group consists of seven to eight, the cephalo-laterals of fourteen to twenty, the caudo-laterals of twenty to twenty-five.

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106. Mytilaspis drimydis Maskell.

Mytilaspis drimydis Maskell, Trans. and Proc. New Zealand Ins., XI, 196.

This is a New Zealand species which infests *Drimys colorata.* The scale is straight, long, and narrow. Average length one-twelfth inch; breadth one-thirtieth inch. Color generally a dirty white, sometimes brown, yellow at the end with the exuviae, which are oval, narrowing somewhat at the tip. The adult female is of a dull red color. The head and thoracic portion of the body are smooth and round. The remainder of the body, on the corrugations, has a row of short, thick, tubular bristles, extending down the edge as far as the commencement of the last segment. There are no groups of spinnerets. Two pairs of lobes well developed.

107. Mytilaspis ficus Signoret.

Mytilaspis flava Targ.-Tozz., Catal. (1868), 44.

This species infests fig in Europe. The scale of the female resembles much that of *M. linearis,* only it is more elongated, and often more curved. The last segment of the female bears five groups of spinnerets. The number of those in the mesal group was not determined; the cephalo-laterals consist each of eight to nine, and the caudo-laterals of six to seven.

108. Mytilaspis flava Targ.-Tozz.

Mytilaspis flava Targ.-Tozz., Catal. (1868), 44.

This species infests olive in Europe. The scale of the female resembles that of *M. linearis,* only it is narrower and covered with a grayish powder. The female is also similar to *M. linearis,* but generally has the segments more pronounced. The last segment bears five groups of spinnerets. The mesal group consists of three, the cephalo-laterals each of six to eight, and the caudo-laterals each of six to seven. The mesal lobes are well developed. The scale of the male is clearer, being almost yellow.

109. Mytilaspis flavescens Targ.-Tozz.

Mytilaspis flavescens Targ.-Tozz., Ann. del Minist. Agric., Ind. e Commerc., 1876, 36.

This species infests oranges and lemons in Europe. The scale resembles that of *Mytilaspis gloverii* which I have described and

figured already. According to Signoret (Essai, 1876, 604), the last segment of the female resembles much that of *Leucaspis pini*, but it bears only a few compound spinnerets. These are arranged in a crown, a group of four or five ending on each side the median curve, which is composed of only one or two.

110. Mytilaspis juglandis Signoret (not of Fitch).

Mytilaspis juglandis Asa Fitch. Signoret, Essai, 1870, 95.

This species infests butternut in Europe. It was supposed by Signoret to be the same as that described by Dr. Fitch under the name of *Aspidiotus juglandis*. But I have carefully examined a specimen of *A. juglandis*, which is probably the type of Dr. Fitch's species, being the one in the collection of the N. Y. State Agr. Society and labeled in his handwriting, and find that it is the same as the species which occurs on apple, and which is known as *M. pomorum*. Therefore the name proposed by Dr. Fitch must be considered a synonym of *M. pomorum*. I have, however, retained the name *juglandis* for the European form occurring on butternut, and cite Signoret's description as the original description of the species. The most important character given by Signoret is the number of spinnerets. There are five groups: the mesal consists of only two, the cephalo-laterals each of six, and the caudo-laterals of five. It is evident from the text that but one specimen was studied.

111. Mytilaspis linearis of authors.

Mytilaspis linearis (Geoffroy) Signoret, Essai, 1870, 96.

This species infests linden in Europe. The scale of the female resembles that of *M. pomorum*. The last segment bears five groups of spinnerets which are almost continuous. The mesal group consists of six to seven, the cephalo-laterals each of ten to twelve, and the caudo-laterals of nine to ten.

112. Mytilaspis metrosideri Maskell.

Mytilaspis metrosideri Maskell, Trans. and Proc. New Zealand Institute, XII, 293, Plate VII, fig. 2.

This is a New Zealand species which infests the rata tree (Metrosideros). The scale is white, pyriform. Female in all

stages dark-colored; in last stage nearly black. Abdomen of female ends in three minute-pointed lobes joined by a scaly process. Spinnerets in an almost continuous arch, which may be resolved into five groups; the spinnerets number seventy or eighty.

113. Mytilaspis phymatodidis Maskell.

Mytilaspis phymatodidis Maskell, Trans. and Proc. New Zealand Institute. XII, 292, Plate VII, fig. 1.

Nothing is given in the description of this species which will separate it from *M. pomorum* except that the scale is broader. The figure represents the lobes as serrate, with long sharp teeth.

114. Mytilaspis pinnaeformis (Bouché).

Aspidiotus pinnaeformis (Bouché), Ent. Zeit. Stett. (1851), XII, 110.
Mytilaspis pinnaeformis (Bouché) Signoret, Essai, 1870, 97.

This species infests Cymbidium in Europe. From the description given by Signoret it is evident that the scale resembles that of *M. pomorum* in color and form; the exuviae occupy about one-third of the whole length of the scale. Upon the last segment of the female there are five groups of spinnerets; the mesal consists of four, the cephalo-laterals each of five, and the caudo-laterals each of four. The male is small, yellowish white, with the thoracic band dark.

115. Mytilaspis pyriformis Maskell.

Mytilaspis pyriformis Maskell, Trans. and Proc. New Zealand, XI, 194.

This is a New Zealand species, the food plant of which is not given by the describer. The scale is broadly pear-shaped. (Maskell's figure resembles a Chionaspis.) The exuviae occupy the smaller end, and the second skin extends to about the middle of the scale. Color of scale light brown; texture thinner than in *M. pomorum,* and form flatter; length about one-twelfth inch; greatest breadth about one-twentieth inch. The last segment of the female bears an almost continuous arch of spinnerets, which consists of two rows with here and there an outlying one. Altogether there may be from sixty to seventy spinnerets in the arch.

Is this a species of Mytilaspis?

116. Mytilaspis saliceti (Bouché).

Aspidiotus saliceti Bouché, Ent. Zeit. Stett., 1851, 110.
Mytilaspis saliceti (Bouché) Targ.-Tozz., Catal., p. 46.

This name was given to a form found on willow (*Salix holosericea*) in Europe. The female is reddish; the scale pale brown.

Genus **POLIASPIS** Maskell

(Maskell, Trans. and Proc. New Zealand Inst., XII, p. 293)

This genus was established by Maskell to include a species of the Diaspinae in which the scales resemble those of Chionaspis but the female differs in presenting eight groups of compound spinnerets.

Although I am far from feeling sure that the genus will prove to be a natural one, I think it best to describe a species which I have found and which is evidently a congener of that described by Maskell under the same generic name that he applied to his species.

117. Poliaspis cycadis n. sp. (Fig. 15).

This interesting scale insect was found in the conservatory of the Department of Agriculture upon *Cycas revoluta* and *Dion edula,* ornamental plants belonging to the order Cycadaceae. It was also found on a species of Microsamia. It usually occurred on the lower sides of the leaves and was not very abundant.

Scale of female.— The scale of the female is snowy white with the exuviae brownish or yellowish, sometimes nearly transparent. The scale is elongated, as in Chionaspis, and much widened toward the caudal end. The length of the largest scales is 3.2 mm. (.12 inch); their greatest width, 1.6 mm. (.06 inch).

Female.— The color of the female is lemon-yellow with the last segment orange. The full-grown insect is oval, broadest in the region of the second and third segments. The characters presented by the last segment are as follows:

There are eight groups of compound *spinnerets*. The mesal consists of two to four, the cephalo-laterals of eight to thirteen, the caudo-laterals of eighteen to twenty-five, the supra-mesal of two to four, and the supra-cephalo-laterals of two to four.

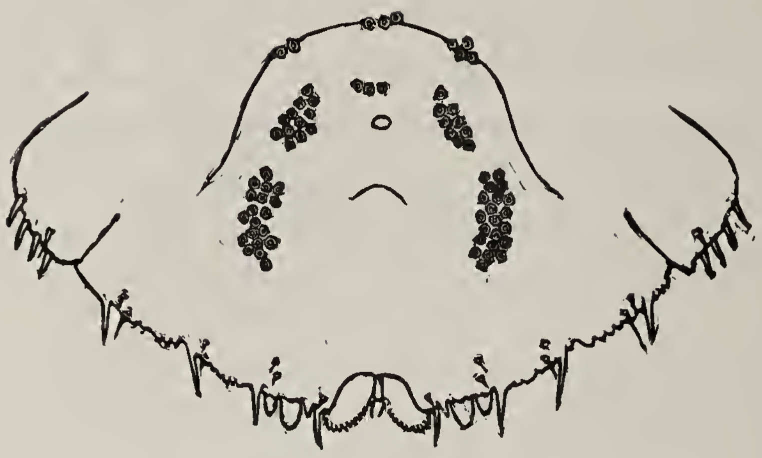

FIG. 15 (Fig. 107, Cornell series)

The mesal *lobes* are prominent, and distinctly serrate on their distal margin. The second lobe is so deeply incised that each division appears like a lobe of itself. The third lobe is usually obsolete. Of twenty-five specimens examined, in only one was the third pair of lobes present. In this case the third lobe of each side was deeply incised, and, as with the second lobe, the lateral division was the smaller.

The *plates* are slender and cylindrical. There is one laterad of each of the first and second lobes and of the place occupied by the third lobe when present. A fourth lobe is present between the third and the penultimate segment. There are from four to six plates on each lateral margin of each of three or four segments cephalad of the last segment.

There are two *spines* between the mesal lobes. On the dorsal surface on each side there are two spines laterad of the first lobe, one cephalad of the other; one on the lateral division of the second lobe, and one a short distance mesad of each of the third and fourth plates. On the ventral surface on each side there is a spine laterad of the mesal lobe, two cephalad of the lateral division of the second lobe, and one mesad of each of the third and fourth plates.

Egg.— The eggs are white when first deposited, later they change to lemon-yellow, and finally become almost orange-yellow when ready to hatch. The number deposited by each female is about one hundred.

Scale of male.— The scale of the male is snow-white, very small, with sides parallel, and the exuviae at one end. It differs from Chionaspis in wanting carinae. The ventral scale is complete. Some of the male scales are completely hidden by a woolly excretion.

Male.— The body of the male is bright orange-red, with the thoracic band of the same color. The eyes are black. The first five segments of the antennae are purplish red, the other five yellow.

SPECIES OF POLIASPIS NOT YET OBSERVED IN THE UNITED STATES

118. Poliaspis media Maskell.

Poliaspis media Maskell. Trans. and Proc. New Zealand Institute, XII, 293.

The scale is white, broad. The adult female, which may reach one-twenty-fourth inch in length, resembles in outline *Mytilaspis pomorum*, is usually greenish white, and bears rudimentary antennae. There are eight groups of spinnerets: four, consisting each of twenty to thirty, are placed in opposite pairs; the fifth, consisting of four to six, is between the upper pair; above these, three other groups form an arch; the two outer ones consist of eight to ten, and the mesal one of three to five. The male insect is of a bright scarlet or deep orange color.

This is a New Zealand species which infests a Veronica and *Leucopogon fraseri.*

GENERA OF DIASPINAE NOT YET OBSERVED IN THE UNITED STATES

Genus **AONIDIA** Targioni-Tozzetti

(Targioni-Tozzetti. Catal., 1868, p. 43)

Female with two scales superimposed; the first presenting at the center a single molted skin surrounded by secretion; the second, from which the first may be removed after a preliminary macera-

tion in water, composed entirely of the second molted skin. The adult female is smaller than this second scale, and consequently smaller than in the most advanced of its adolescent stages. Scale of the male similar to that of Aspidiotus. Represented by a single described species.

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119. Aonidia lauri (Bouché).

Aspidiotus lauri Bouché. Schald (1833), 53.
Chermes lauri Bouché. Boisduval, Ent. Hort. (1867), 340.
Aonidia purpurea Targ.-Tozz., Catal. (1868), 43.
Aonidia lauri Bouché. Signoret, Essai, 1870, p. 103.

This species infests the leaves of the laurel (*Laurus nobilis*) in Europe. Targioni believes it to be the *Coccus aonidum* of Linnaeus; and, contrary to the established rules of nomenclature, renames it *Aonidia purpurea,* using the old specific name for the new genus. Signoret recognizes the new genus, but does not consider the species in question to be that described by Linnaeus. He therefore refers to it as *Aonidia lauri* Bouché.

Genus **LEUCASPIS** Targioni-Tozzetti

(Targioni-Tozzetti, Catal., 1868, 41 [without description]; Signoret, Essai, 1870, p. 100)

The last abdominal segment of the female is fringed with a series of blunt spiny hairs. The scales are similar to those of the females of Chionaspis. The arrangement of the spinnerets differs widely in the two known species.

120. Leucaspis signoreti Targ.-Tozz.

Leucaspis signorèti Targ.-Tozz., Catal. (1868), 42.
Leucaspis signoreti Targ.-Tozz. Signoret, Essai, 1870, 100.

Infests leaves of pine in Europe; scales of both sexes white, with exuviae light yellow.

121. Leucaspis pini (Hartig).

C. pini Hart., Jahr. über die Forsch. des Forstwers. (1839), 642.
A. pini Bouché, Ent. Zeit. Stett. (1851), XII, 110.
Leucaspis candida Targ.-Tozz., Catal. (1869), 41.
Leucaspis pini Hartig. Signoret, Essai, 1870, p. 102.

Infests leaves of pine in Europe.

LIST OF AMERICAN COCCIDAE NOT DESCRIBED IN THE PRECEDING PAGES

The following list includes the names of all the Coccidae not belonging to the subfamily Diaspinae which I have found described as occurring in North America. Owing to lack of time, but little effort has been made to determine the validity of the species enumerated. The genera and the species under each genus are arranged alphabetically.

122. Asterodiaspis quercicola (Bouché).

This species infests oak at Washington, D. C. See Agr. Report 1880, page 330, and Plate XI, fig. 9, of that report. A more careful study of this species has convinced me that it does not belong to the Diaspinae.

123. Carteria lacca (Kerr).

This is the insect which furnishes the lac dyes and the shellac of commerce. Although not an American insect, I have included it in this list on account of its economic importance. For description and figures, see my report in Agr. Report 1881, page 209 and Plate XIX.

124. Carteria larreae Comstock.

This is a lac insect which infests the creosote plant (*Larrea mexicana*), in the southwestern portions of the United States and in Mexico. See Agr. Report 1881, page 211.

125. Carteria mexicana Comstock.

This is a lac insect which infests mimosa at Tampico, Mexico. See Agr. Report 1881, page 212.

126. Cerococcus quercus Comstock.

Infests oak in Arizona and California. This species is remarkable for the large amount of wax which it excretes. See Agr. Report 1881, page 213.

127. Ceroplastes cirripediformis Comstock.

This species was found in Florida on myrtle, orange, quince, and a species of Eupatorium. See Agr. Report 1880, page 333.

128. Ceroplastes floridensis Comstock.

This species infests orange, lemon, fig, pomegranate, guava, tea, quince, Japan plum (Biotrites), oleander, red bay, sweet bay, gall berry (*Ilex glabra*), myrtle, and Andromeda, in Florida. See Agr. Report 1880, page 331, and Plate IV, figs. 2, 2*a*, and 2*b*.

From this species I bred a hymenopterous parasite of the genus Tetrastichus. See l. c. 369.

129. Ceroplastes jamaicensis White.

Infests trunk of lancewood tree in Jamaica. White, Ann. Nat. Hist., XVII, 333, and Westwood, Gardeners' Chronicle, 1853, 484.

130. Coccus bassi Targ.-Tozz.

This is a Mexican species mentioned by Targioni-Tozzetti, Stud. sulle Cocc., 1867, 27, and Catal. (1868), 32.

131. Coccus cacti of authors.

The cochineal insect occurs upon cactus in Florida. See Agr. Report 1880, page 346.

Coccus pinnicorticis Fitch.

This is the name given by Fitch (Trans. N. Y. State Agr. Society, Vol. XIV [1854], 871) to a plant louse which is often mistaken for a coccid.

132. Dactylopius adonidum of authors.

Coccus adonidum Linn., Syst. Nat. (1767), 740.
Dactylopius adonidum Signoret, Essai, 1875, 306.
Lecanium phyllococcus Ashmead, Canadian Entomologist, XI (1879), 160.

This is the common mealy bug. See Agr. Report 1880, 341.

133. Dactylopius destructor Comstock.

This is a mealy bug which is very destructive to oranges in Florida. See Agr. Report 1880, 342.

134. Dactylopius longifilis Comstock.

This is a mealy bug common on many plants in the conservatories at Washington. See Agr. Report 1880, 344.

Dorthesia.

See *Orthezia.* See also *Icerya purchasi,* which has been determined by several writers as a Dorthesia.

Dorthesia celastri.

Glover states (Agr. Report 1876, 45) that Dr. Fitch mentions a species, *Dorthesia celastri,* which is found on Celastrus. I have been unable to find the reference in Fitch's writings. But in the Fitch collection I saw what I believe to be the egg masses of *Euchenopa binotata* labeled with this name.*

Dorthesia viburni Fitch.

Under this name also Dr. Fitch distributed specimens of the peculiar egg masses of *Euchenopa binotata* Say. I cannot find, however, that the name was published.

135. Eriococcus azaleae Comstock.

Infests azalea. I have found it at Washington, and in a hothouse at Geneva, N. Y. See Agr. Report 1880, 338.

From this species I have bred the chalcid parasite *Coccophagus immaculatus* Howard. See Agr. Report 1880, 358.

136. Icerya purchasi Maskell.

Infests orange, rose, acacia, and many other plants in California. See Agr. Report 1880, 347.

137. Kermes galliformis Riley.

Infests oak. See Agr. Report 1880, 337, and American Naturalist, Vol. XV (1881), 482.

From species of Kermes I have bred the following chalcid parasites: a species of the genus Telenomus, and *Cosmocoma elegans* Howard. See Agr. Report 1880, pages 370 and 371.

138. Lecanium antennatum Signoret.

Infests oak. Described by Signoret (Essai, 1873, 413), from specimens received from Dr. Asa Fitch.

* For a description and figure of *Euchenopia binotata,* see Agr. Report 1876, page 28.

139. Lecanium caryae Fitch.

Infests hickory. See Trans. N. Y. State Agr. Society, 1856, 443. There is a typical specimen of this species in the collection of the above-named society. Mr. J. D. Putnam bred the chalcid parasite *Chiloneurus albicornis* Howard. See Agr. Report 1880, 363, and Plate XXIII, figure 4 (not Plate I, as stated).

140. Lecanium cerasifex Fitch.

Infests cherry. See Trans. N. Y. State Agr. Society, 1856, 368. From Fitch's notes it is evident that this species was described from two specimens. I saw one specimen in his collection in 1881. There is none in the collection of the N. Y. Agr. Society.

141. Lecanium corylifex Fitch.

Infests hazelnut. See Trans. N. Y. S. Agr. Society, 1856, 473. I have been able to find no specimens in existence labeled by Dr. Fitch as *L. corylifex.* But among the duplicates in the Fitch collection, I saw many specimens labeled *L. coryli.* And I have one which Professor Uhler received from Dr. Fitch labeled in the same way. In Dr. Fitch's notes on *L. corylifex,* he gives as a synonym of the species *Coccus coryli* (?) Lin., Sys. Nat., II, 741. I believe, therefore, that the specimens labeled by Fitch as *L. coryli* may be taken as the types of his *L. corylifex.* It is worthy of note that in no instance have I seen the word *type* written on one of his labels.

142. Lecanium cynosbati Fitch.

Infests stalks of wild gooseberry. See Trans. N. Y. State Agr. Society, 1856, 436. From Fitch's notes it is evident that this species was described from a single specimen. This specimen I saw in the Fitch collection in 1881.

143. Lecanium fitchii Signoret.

Infests raspberry or blackberry. See Signoret, Essai, 1873, 404.

144. Lecanium filicum Boisduval.

Infests ferns. Described by Boisduval in his Essai sur l'Ento-

mologie Horticole, 335. There is a fuller description by Signoret in his Essai, 436. Packard records* the presence of this species in this country.

145. Lecanium hemisphaericum Targ.-Tozz.

Infests orange, oleander, and many other plants. See Agr. Report 1880, 334.

146. Lecanium hesperidum Linn.

Infests oleander, orange, and many other plants. See Agr. Report 1880, 335. In addition to the three parasites enumerated in the report just quoted, I have bred *Coccophagus lecanii* (Fitch) from this species. See l. c., 357.

147. Lecanium juglandifex Fitch.

Infests butternut. See Trans. N. Y. State Agr. Society, 1856, 463. There is a typical specimen in the collection of the N. Y. S. Agr. Society.

148. Lecanium oleae Bernard.

This is what is known as the black scale in California. It infests orange, olive, oleander, and many other plants. See Agr. Report 1880, 336.

149. Lecanium persicae (Fabricius).

Infests peach. For description see Signoret, Essai, 1873, 407. Also Fitch, Trans. N. Y. State Agr. Society, 1856, 357.

150. Lecanium platycerii Packard.

Infests the staghorn fern (Platycerium). See Packard, *Injurious Insects*, etc., 1870, pages 28 and 31.

151. Lecanium pyri Fitch.

Infests pear. See Trans. N. Y. State Agr. Society, 1854, 809. Under this name Fitch has described two distinct species, one a Lecanium and the other a Pulvinaria. He evidently considered the former an immature stage of the latter. There is a typical

*Injurious insects, etc., 1870, p. 27.

specimen in the collection of the N. Y. S. Agr. Society which is a Lecanium; and I saw both a Lecanium and a Pulvinaria in the Fitch collection labeled *Lecanium pyri.*

152. Lecanium quercus (Linn).

Infests oak. For description, see Signoret, Essai, 1873, 427. The specimen which served as the type of Signoret's description was received from Dr. Asa Fitch.

153. Lecanium quercifex Fitch.

Infests white oak. See Trans. N. Y. State Agr. Society, 1858, 805. I have been unable to find any specimens labeled by Fitch as *Lecanium quercifex.* But there are in both the N. Y. State Agr. Soc. collection and the private collection of Fitch specimens labeled "White Oak Scale insect, *Lecanium querci.*" As white oak scale insect is the popular name given by Fitch in the published description of *L. quercifex,* I think these specimens must be those which he had before him when he wrote the description of *L. quercifex.*

154. Lecanium quercitronis Fitch.

Infests black oak. See Trans. N. Y. State Agr. Society, 1858, 805. Typical specimens of this species are in the collection of the N. Y. S. Agr. Society. This species is infested by the chalcid parasite *Coccophagus lecanii* Fitch.

155. Lecanium ribes Fitch.

Infests currant. See Trans. N. Y. State Agr. Society, 1856, 427. Although Fitch states that this species was common in some gardens, there are no specimens in the collection of the N. Y. S. Agr. Society; and in his private collection there is only a single specimen which is in very poor condition.

156. Lecanium sallei Signoret.

This is a Mexican species the food plant of which is unknown. See Signoret, Essai, 1873, 410.

157. Lecanium tiliae (Fitch).

Infests linden. See Fourth Annual Report of the Regents of the University of the State of New York (1851), page 69. I have been unable to find the type of this species in either of the collections where it should be.

158. Lecanium tulipiferae Cook.

Infests the tulip tree. See Canadian Entomologist, vol. X (1878), 192.

I think this will prove to be *Lecanium tiliae* (Fitch).

159. Lecanium verrucosum Signoret.

This is a Mexican species the food plant of which is unknown. See Signoret, Essai, 1873, 442.

160. Orthezia americana Walker.

Infests goldenrod (Solidago), burdock (Arctium), Impatiens, Eupatorium, and probably many other native plants. See Agr. Report 1880, 349.

After this genus had been established an effort was made to change the name to Dorthesia; hence we find both names in the books. See *Dorthesia*, above.

161. Pseudococcus aceris (Geoffrey).

Infests maple. See Agr. Report 1880, 345. This species is infested by the chalcid parasite *Rhopus coccois* (E. A. Smith). See l. c., 361.

162. Llaveia aximus (Hernandez).

This is a Mexican species which is said to be about one inch long (23 to 25 mm.). It infests *Jatropha curcas* and *Spondias myrobolanus*. Signoret states that it is employed in Mexico as a fat and as varnish, and that in its first state it appears to be used in medicine as an anodyne. See Signoret, Essai, 1875, 371.

163. Pulvinaria innumerabilis Rathvon.

Coccus innumerabilis Rathvon, Pennsylvania Farm Journal, Vol. IV (1854), 256–8.
Lecanium acericorticis Fitch. Trans. N. Y. State Agr. Soc., 1859, 775.
Lecanium acericola Walsh and Riley, American Entomologist, Vol. I, 14.
Lecanium maclurae Walsh and Riley, American Entomologist, I, 14.

This species infests maple, Negundo, grape, osage orange, and probably other plants. For figure, see Agr. Report 1880, Plate XI, fig. 6. In addition to the works cited above, interesting papers upon this species will be found in the Proceedings of the Davenport Academy of Sciences, Vol. II, and in the American Naturalist, Vol. XII, 655. See *P. vitis*.

From this species Mr. J. D. Putnam bred the chalcid parasite *Aphycus pulvinariae* Howard (see Agr. Report 1880, 365), and I have bred *Coccophagus lecanii* (Fitch) and the pyralid parasite *Dakruma coccidivora* Comstock (see Agr. Report 1879, 241).

164. Pulvinaria pyri (Fitch).

Infests pear. This is the *Lecanium pyri* of Fitch in part. Is it not the same as *Pulvinaria innumerabilis*?

165. Pulvinaria salicis (Bouché).

Infests willow. It was received by Signoret from Dr. Fitch. See Signoret, Essai, 1873, 44. Is not this also the same as *Pulvinaria innumerabilis*?

166. Pulvinaria vitis of authors.

Infests grape. See Signoret, Essai, 1873, 45. It may be that our *Pulvinarid innumerabilis* will prove to be identical with this species.

167. Rhizococcus araucariae (Maskell).

Infests Norfolk Island pine (Araucaria). See Agr. Report 1880, page 339.

168. Rhizococcus quercus Comstock.

Infests oak, gall berry, and grass. See Agr. Report 1880, page 340.

INDEX TO PLANTS

In the following list are given the names of the plants cited in this report as food plants of scale insects. The species which infest each plant are referred to by number. Certain species infest a large number of plants and are thus liable to be found on other plants than those indicated here. Among these species are nos. 10, 13, 15, 17, 132, 134, 148, and 146.

INDEX TO SCALE INSECTS

Except where the word *page* occurs, the figures refer to the numbers which the species bear in this report. Synonyms are in italics, and generic names in small capitals.

EXPLANATION OF PLATES

PLATE I

Organs of the last segment of adult females of the Diaspinae; diagrammatic; each letter has the same significance throughout.

a. Vaginal opening.

b. Anus.

c. Mesal group of spinnerets (anterior group of report for 1880).

d. Cephalo-lateral group of spinnerets (anterior laterals of report for 1880).

e. Caudo-lateral group of spinnerets (posterior laterals of report for 1880).

f^1, f^2, f^3. Lobes.

f^1. First pair of lobes, or mesal lobes.

f^2, f^2. Second pair of lobes.

f^3, f^3. Third pair of lobes.

g. Thickened lateral margin of segment.

h. Club-shaped thickenings of body wall.

i. Incisions.

j. Thickened margins of incisions.

k. Spines (not represented in figure 2, to avoid complication).

l. Plates (frequently described by authors as spines).

m, m^1. Wax ducts.

n. Elongated pores (Fig. 2).

PLATE II

Scales of the Diaspinae, from camera lucida drawings. 1, *Aspidiotus ficus,* female; 1*a,* male of same; 2, *Aspidiotus nerii,* female; 2*a,* male of same; 3, *Diaspis rosae,* female; 3*a,* male of same; 4, *Chionaspis furfurus,* female; 4*a,* male of same; 5, *Mytilaspis pomorum,* female; 5*a,* male of same; 6, *Parlatoria pergandii,* female; 6*a,* male of same; 7, *Parlatoria proteus,* female; 7*a,* male of same; 8, *Parlatoria zizyphi,* female; 9, *Uhleria camelliae*; 10, *Aspidiotus* (?) *parlatoroides,* female; 11, *Chionaspis* (?) *biclavis.*

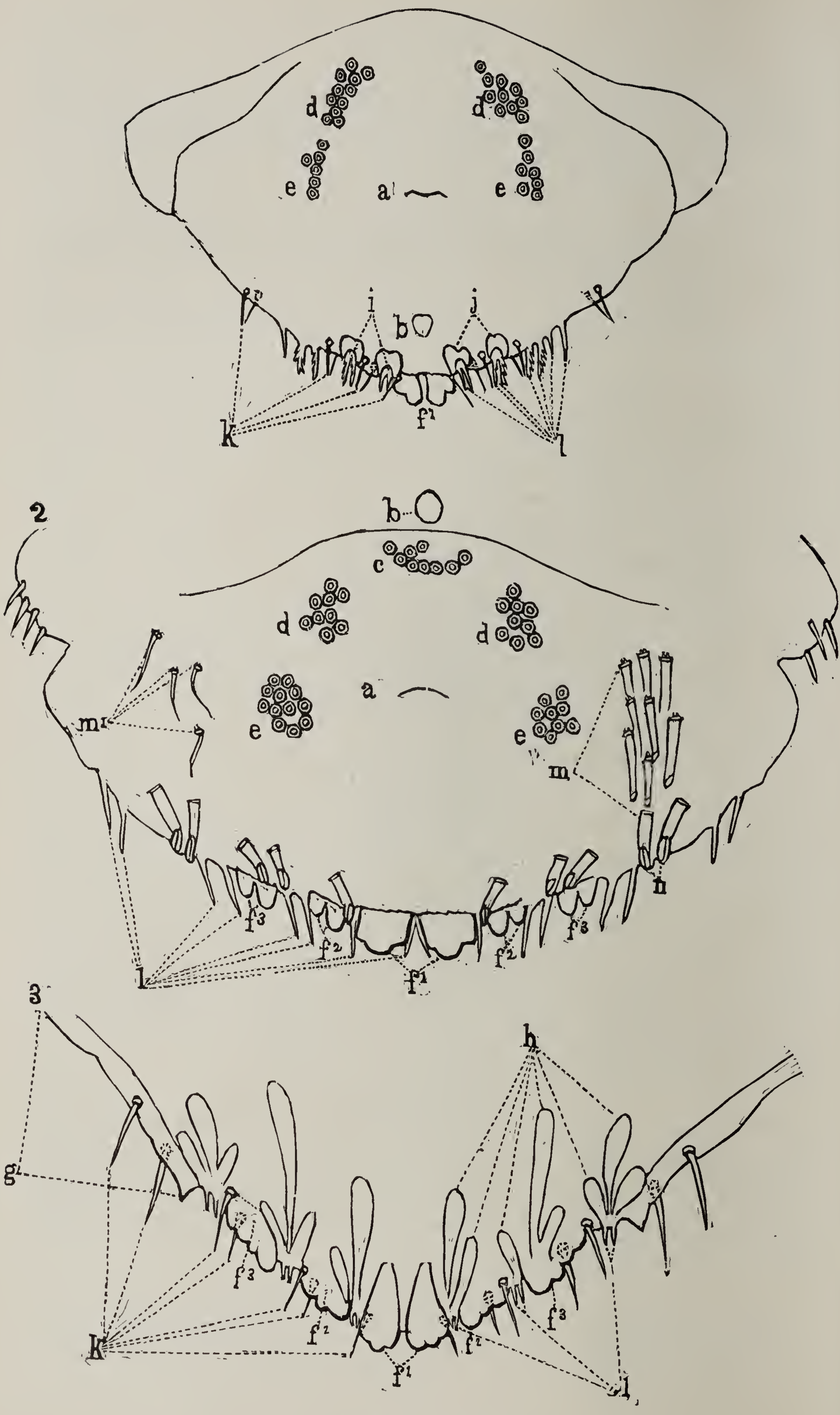
PLATE III

Fig. 1—1*c, Aspidiotus* (?) *sabalis*; 1, scales of male and female; 1*a,* antenna of male; 1*b,* antenna of female; 1*c,* last segment of adult female. Fig. 2, *Aspidiotus personatus,* female; 2*a,* caudal margin of same. Fig. 3, *Chionaspis spartinae,* last segment of female; 3*a,* margin of same.

PLATE IV

Fig. 1, *Parlatoria zizyphi.* Fig. 2, *Parlatoria pergandii.* Fig. 3, *Parlatoria proteus.* Fig. 4, *Parlatoria pergandii* var. *camelliae.*

PLATE I

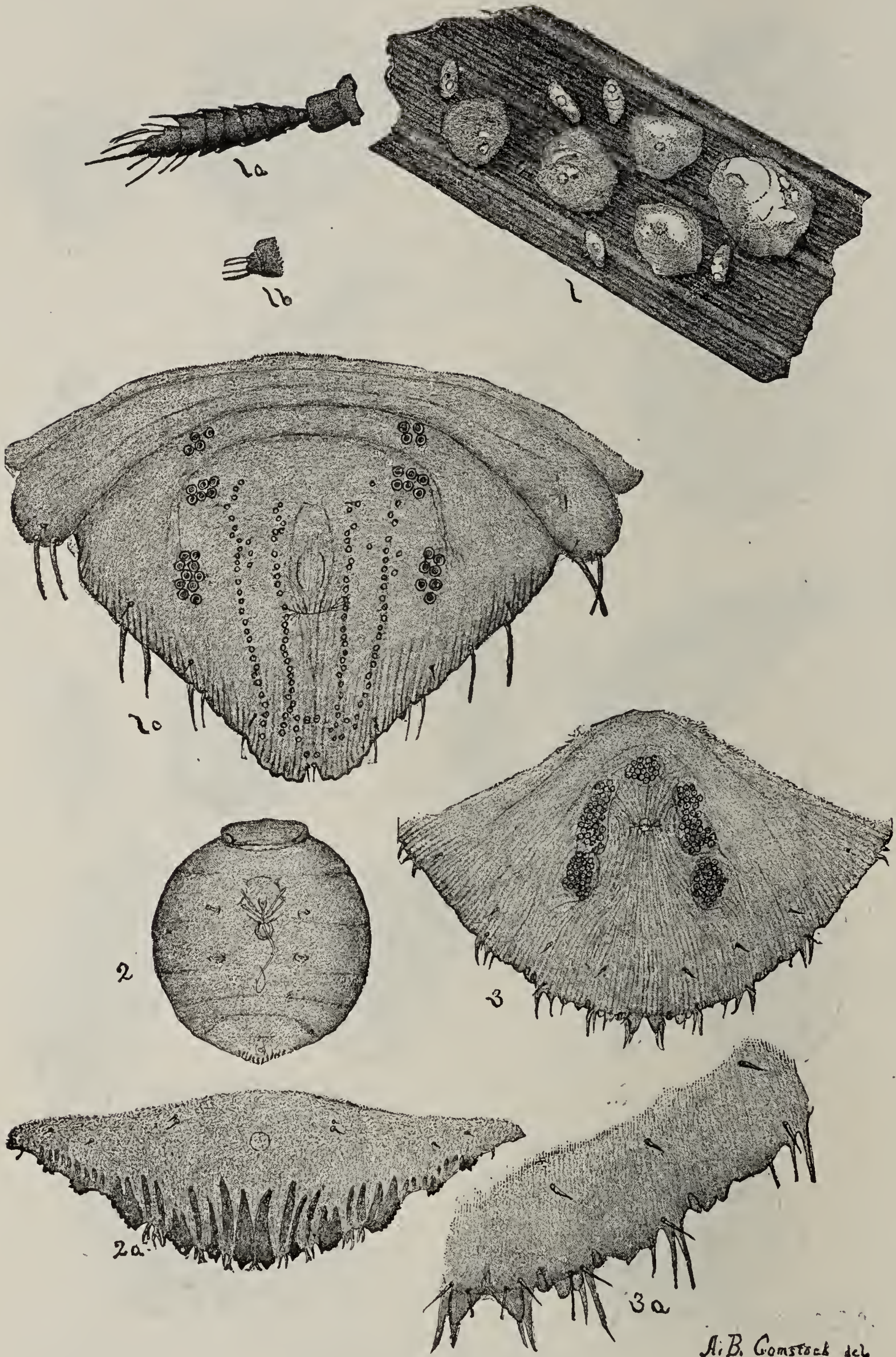


(Plate XXXIII, Cornell series)

PLATE II

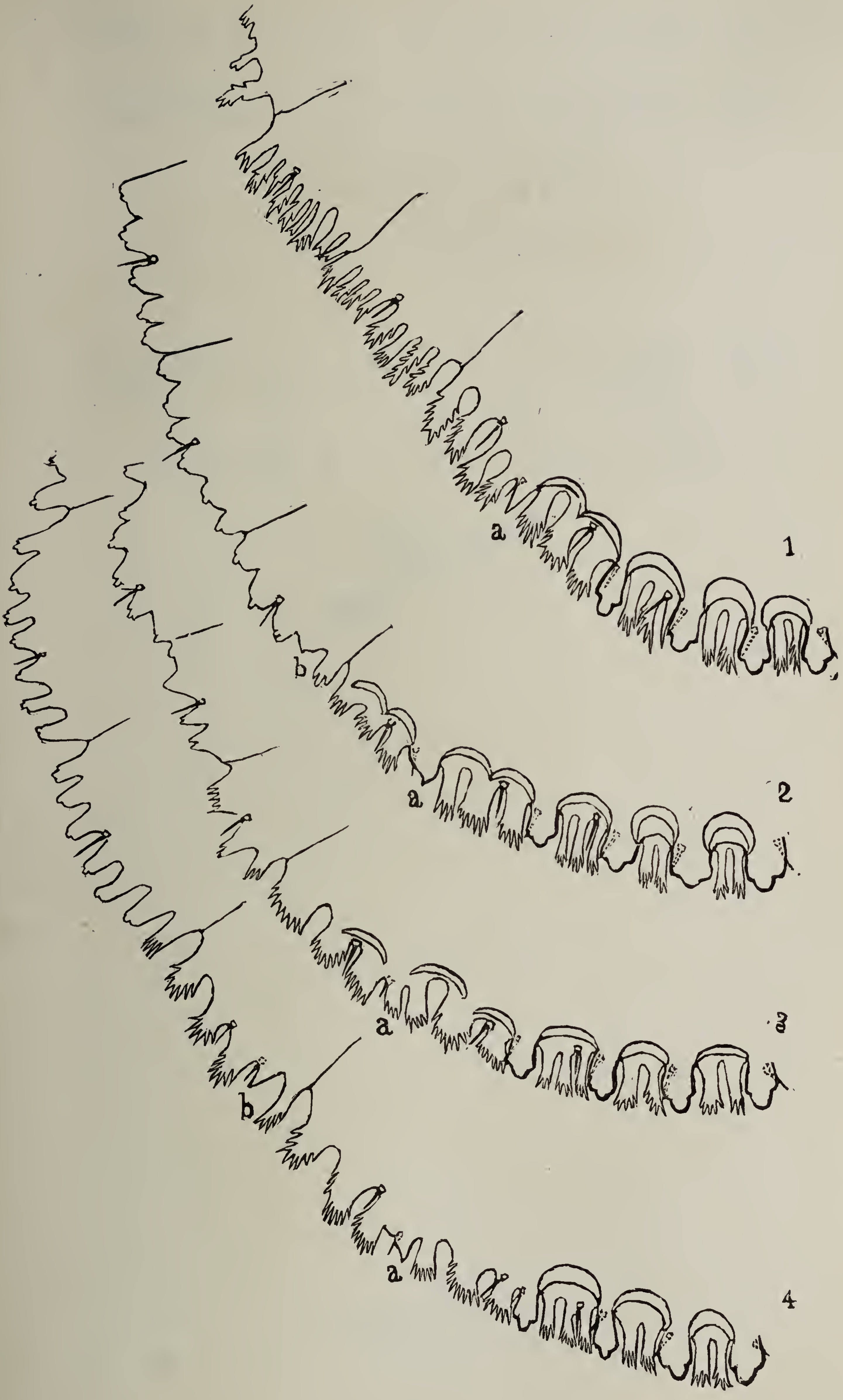
(Plate XXXIV, Cornell series)

PLATE III



(Plate XXXV, Cornell series)

PLATE IV



(Plate XXXVI, Cornell series)

APRIL, 1916 BULLETIN 373

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF THE
NEW YORK STATE COLLEGE OF AGRICULTURE

BEVERLY T. GALLOWAY, Director

Department of Dairy Industry

METALLIC FLAVOR IN DAIRY PRODUCTS

E. S. GUTHRIE

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CONTENTS

METALLIC FLAVOR IN DAIRY PRODUCTS

E. S. Guthrie

The sale of dairy products depends largely on their flavor. Many flavors do not materially affect the sale of dairy goods, but, on the other hand, there are several that directly affect their price. Metallic flavor belongs to the latter class, and may reduce the price of butter from one to two cents a pound.

Metallic flavor as such was not of great importance until about twelve years ago. So far as the writer is able to determine, the first person to detect this flavor was B. D. White, who states that in 1901, when he was an assistant commissioner on the Dairy and Food Commission of Minnesota, that commission instituted a monthly scoring contest for butter in conjunction with the Minnesota Agricultural School. In this contest Mr. White criticized the butter, explaining any abnormal flavors or defects found. Various flavors were detected, among them a new flavor, which was designated as metallic, a curdy flavor, and a feverish, or cowy, flavor. It was noticed later, after publication of those criticisms, that other States had adopted the same terms in criticizing butter, and the question was whether the same flavors were recognized or whether the terms were applied to other flavors. Later, however, in monthly scoring contests conducted by the National Creamery Buttermakers' Association in connection with the United States Department of Agriculture, in which Mr. White was critic, the same terms were used, and in that way they were carried through the United States rather thoroughly and the various judges who attended the different scorings became familiar with them.

The character of metallic flavor has been determined through personal correspondence with noted authorities on butter in this country, and with one expert in Denmark, one of the greatest butter countries in the world. These men are as follows: Professor Bernhard Boggild, Royal Veterinary and Agricultural College, Copenhagen, Denmark; F. W. Bouska, formerly professor of dairy bacteriology at Iowa State College, now with the Beatrice Creamery Company, Lincoln, Nebraska; C. E. Croomer, manager of the butter department of the Fox River Butter Company, Chicago, Illinois; C. W. Fryhofer, formerly federal butter expert on the New York City market, now in the Dairy Division of the United States Bureau of Animal Industry; Professor N. W. Hepburn, University of Illinois; J. C. Joslin, formerly federal butter expert on the Chicago market; P. H. Kieffer, President of the Gude Brothers Kieffer Company, New York City; Professor C. Larsen, South Dakota State College and Experiment Station;

Professor C. E. Lee, University of Wisconsin; Robert McAdam, formerly in charge of renovated butter inspection, Dairy Division, United States Bureau of Animal Industry; G. L. McKay, formerly professor of dairying at Iowa State College, now secretary of the American Association of Creamery Butter Manufacturers; Professor M. Mortensen, Iowa State College; Professor A. B. Nystrom, State College of Washington; S. E. Thompson, in charge of dairy manufacturing investigations, Dairy Division, United States Bureau of Animal Industry; B. D. White, formerly in charge of dairy manufacturing investigations, Dairy Division, United States Bureau of Animal Industry; Professor J. H. Frandsen, University of Nebraska; H. J. Credicott, formerly federal butter inspector on the Chicago market.

According to Fryhofer, Kieffer, Hepburn, McKay, Lee, Thompson, and Nystrom, metallic flavor is similar to the flavor of rusty iron. Lee, Croomer, Thompson, and Fryhofer state that there is a similarity between fishy flavor and metallic flavor. Thompson says: "It is classified as fishy, oily, tallowy, etc. I believe, however, that it is safe to say that the true metallic flavor is easily recognized by men qualified to judge of such things, after they have once become familiar with it."

The detection of metallic flavor is difficult. In order to determine whether there is any uniformity of judgment as to this flavor, the writer took a sample of butter pronounced metallic by the butter judges of the Department of Dairy Industry at Cornell University, to the National Dairy Show, for the criticism of some of the experts already named. It was inspected by McKay, Larsen, Thompson, Kieffer, Joslin, Lee, Hepburn, Frandsen, and Credicott. Every one of these men said that without doubt the flavor was metallic. In each of the criticisms, more than one judge examined and criticized the product. In case only two judges were present, and one reported in the affirmative while the other decided in the negative, the result was counted as negative. But if there were four judges, and two pronounced the flavor metallic while the other two reported it not metallic, the sample was counted as metallic, with one exception. There was no particular reason for this decision, aside from the fact that if two judges found metallic flavor it would seem that it must be present in a slight degree. When three or five judges made the examination, the majority report was taken.

GENERAL OBSERVATIONS

PERIOD OF OCCURRENCE

Croomer and Larsen claim that metallic flavor in butter is found oftenest in early spring and late fall; Kieffer and McAdam say that it is commonest

in late fall and winter; Hepburn, McKay, and Fryhofer say that it is commonest during the hottest time of the year; and Nystrom observes that it is commonest in the fall. Thompson says: "The extent or frequency with which this trouble occurs, I am unable to determine. It is apparently confined to no particular section or season, but may occur anywhere and at any time." This last opinion — that is, that metallic flavor "may occur anywhere and at any time"—is supported by Croomer, Hepburn, McKay, Larsen, and Fryhofer.

CAUSES OF METALLIC FLAVOR

Joslin and McKay think that pasteurization is a factor in the production of metallic flavor in butter. Mortensen and Melick (1912)[1] on the other hand, claim that if pasteurization is properly done it prevents the development of the flavor.

Thompson, Fryhofer, McKay, Joslin, White, and the New York Produce Review and American Creamery (1912), state that there seems to be a definite relationship between high acidity and metallic flavor.

White, McAdam, Croomer, and Kieffer think that metallic flavor is due directly to metals.

Brown (1912) states that he has known the first of the two churnings from a ripener to come out with a fine flavor, and the next one, some two hours later and held at a temperature of 46° F., to come out with a bad metallic flavor. He says that when there was any metallic flavor at all it was invariably the worse in the latter churning.

Melick (1912) observed that cream seemed to develop metallic flavor near its surface. He attributed this to certain atmospheric conditions, since no metallic flavor appeared when the vats were carefully closed.

Boggild writes: "We here in Denmark have for a long time known that the same or a similar taste [referring to the metallic flavor] in butter can be due to rusty utensils, and in some cases to bacteria, and also that the so-called fishy flavor is due to microorganisms."

Coinciding with Boggild's idea that a microorganism is the cause of fishy flavor, the New York Produce Review and American Creamery (1912) makes the following statement: "We will not attempt to assign causes for all flavors in butter resembling the 'metallic.' Doubtless such defects may have a bacterial origin as well as an origin actually associated with metals with which the more or less acid cream has come in contact."

The following extract is from Irish Homestead (1913):

In some Irish creameries, particularly in those where pasteurization has been attempted, regardless of the percentage of fat in the cream, a flavor that somewhat resembled "fishiness" was experienced. Although it did not entirely coincide with "fishiness," the resemblance was close, but it may be more accurately described as

[1] Dates in parenthesis refer to bibliography, page 628.

a " metallic " flavor, possibly due to some organic cause. This flavor was invariably noticed in butter the cream of which contained over 35 per cent of fat, and it was particularly noticeable where the fat content in the cream ran over 40 per cent and up to 50 per cent, when the cream was pasteurized. In some cases the flavor was even noticeable where the whole milk was not heated beyond 130° F., and where the cream was not pasteurized.

It is, of course, evident that whether milk or cream is pasteurized, the cream for buttermaking should not contain more than 33 per cent of fat, and the results, particularly as regards the keeping qualities of the butter, are much more likely to be satisfactory where a thin cream, not containing over 30 per cent of butterfat, is separated and then thoroughly pasteurized, well cooled down, ripened at a moderately low temperature, with a liberal supply of clean, active starter to an acidity of 0.3 to 0.35, but in no case exceeding 0.4.

In the most progressive and highly successful dairying countries of Europe it is the general practice all through the year to separate a thin cream — in most cases the cream does not contain over 25 per cent of butterfat, while in one large dairying country the cream rarely contains over 20 per cent of butterfat, and pasteurization is general among all the creameries. . . . .

PRELIMINARY WORK

The observations on metallic flavor made in the laboratories at Cornell University were as follows:

I. High acid content seemed essential for the development of the flavor.

Every instance in which metallic flavor was found in the preliminary work was in a product of high acidity, and only twice did the writer hear of its being noted in sweet dairy products. In one case a milk company reported metallic flavor in sweet milk, but it was of short duration. The second case was reported by White, who wrote: "I have always found the metallic flavor in condensed milk and believe that this is due entirely to the raw copper of condensing pans." The writer has never noticed this flavor in condensed milk, nor has he detected it in swiss cheese, another dairy product made in a copper container.

The chemist would say that there is far greater probability of a metal's being absorbed by an acid solution than by a non-acid one. Nevertheless it is true that some dairy products of very high acidity have been held in containers with exposed surfaces of metals that easily combine with lactic acid to form lactates, such as copper and iron, and have not developed a metallic flavor that could be detected by expert judges of that flavor. The tin of the starter can in the butter laboratory at Cornell is almost entirely off. Starter has been cultivated daily in this can for three or four years; it has been carefully examined many times for metallic flavor, and this has been present in only a few cases.

It is possible that electrolytic action plays an important part in the production of metallic flavor when the source is directly from metal.

II. The flavor was most likely to appear during the hottest season.

It may be that this was noticeable because the degree of acidity of the product is likely to be greater when the temperature is high.

III. A high fat content seemed necessary for the development of the flavor, except in the case of buttermilk.

These observations, which were made two years before the report of Irish Homestead already quoted was published, seemed to indicate that metallic flavor developed more rapidly and to a greater extent in cream that was rich in butterfat than in cream with a low fat content. The flavor was very strong in some samples of soft cream cheese, but was never noticed in cottage cheese, which contains practically no butterfat. Whenever the flavor was found in whole milk, it was always near the surface, in the cream, and it was never observed in skimmed milk. For some reason, however, it was often found in buttermilk. With the exception of buttermilk, metallic flavor was never found in a dairy product that was low in butterfat content.

IV. The flavor appeared spasmodically.

Often metallic flavor could not be detected in butter for several weeks, and sometimes for many months, after which it suddenly appeared for perhaps a few days, or possibly for several weeks. During all this time the same utensils were being used on the farms and in the creamery laboratories.

V. Low temperatures often seemed to make the flavor more apparent.

The low temperatures in the laboratories may have held in check certain organisms that at high temperatures produce sufficiently strong flavors to cover the metallic flavor.

The preliminary observations thus seemed to indicate that there may be a cause of metallic flavor other than direct contact of the dairy product with metal. In fact, it was quite apparent that there may be a biological reason for the development of metallic flavor, for in several instances it seemed to increase when the product was not in contact with metal.

WORK OF OTHER INVESTIGATORS

Some work has been done of a more scientific nature than that just described. The most recent is that of Rogers, Berg, Potteiger, and Davis (1913), who report, besides their own work, researches by several other investigators. The following abstract of their bulletin appeared in a press notice sent out by the United States Department of Agriculture:

> Some metals either cause or greatly accelerate certain bad flavors in butter, although most of the experiments along this line have not included storage butters. Recently the scientific staff of the Dairy Division of the Bureau of Animal Industry in the United States Department of Agriculture has reported that the presence of very small amounts of iron in cream causes certain undesirable flavors to increase in intensity during storage. These flavors are often designated by butter experts as "metallic," "oily," or "fishy." The injurious effect of iron was found by adding iron in known quantities, varying from 1 to 500 parts, to 1,000,000 parts of cream. The butter made from such cream was compared with that made from cream where all precautions were taken to avoid any undue contact with iron during the whole process of butter-making. The butter was stored at 6° to 10° F., and the quality of the butter was scored by experts at different times. In every instance when the butter was scored a few days after making, the samples to which iron had been added scored lower than the butter made from cream which contained no iron. This held true in most cases on the second and third scoring,

which occurred at intervals varying from 20 to 187 days. The most noticeable feature was the rapid development of bad flavor in the butter containing the iron. When both the control and the experimental butter became fishy it was noticed that the control butter was the last to become so. There was a marked oily flavor present in most samples that subsequently became fishy. Only a small proportion of the iron added to the cream was found in the butter, the remainder having been taken up by the buttermilk and wash water.

Butter was also made from cream which had stood in rusty cans, and in every case this butter had a peculiar taste and was easily picked out from all other samples. The buttermilk also had a decided metallic taste.

The influence of copper on the flavor of butter was studied in a similar manner, and it was found that copper, even in small quantities, seemed to cause more marked changes of flavor in butter than did the iron, with a decided tendency toward a fishy flavor in storage. Two experiments showed very plainly the harmful effect of using poorly tinned pasteurizers, even though the cream came in contact with the copper surface for only a few seconds, for, aside from this, all other conditions were exactly alike during the complete process of butter manufacture.

This work shows that if cream is kept in rusty cans or comes in contact with iron or copper at any time during the process of butter-making it may take up iron or copper from rusty cans, exposed bolt heads, or other metal parts of pasteurizers or churns, in sufficient quantities to affect the flavor of storage butter. Though there is nothing to show that the nature of the flavor is appreciably changed, it does demonstrate very clearly that the rate of development of the undesirable flavor is greatly accelerated during storage by very small quantities of either iron or copper.

Golding and Feilmann (1905) think that microorganisms may be the fundamental cause of metallic flavor. However, they attribute the cause largely to contact of the product with exposed surfaces of copper. They found that milk passed over an untinned copper cooler took up 2.5 parts of copper in 10,000,000 parts of sweet milk, and, though the characteristic flavor was not at once apparent, it invariably was perceptible in about eighteen hours at room temperature. They observed that air aids greatly in the solution of copper in milk. Clean copper gauze fixed on the surface of some milk in a beaker and left for one week resulted in the solution of 121 parts of copper in 1,000,000 parts of milk. At the bottom of the beaker only 48 parts per million were dissolved. They say:

The chemistry of the flavour is still only a matter of speculation, but similar flavours can be produced by other oxidising agents, such as potassium permanganate, ferric chloride and hydrogen peroxide.

A large number of organisms were isolated from the different samples of milk which had developed the characteristic flavour; but none of them developed the flavour in milk which had been sterilised by heat. When, however, the influence of the copper had been discovered, the experiments were repeated, and the flavor seemed to be developed by certain organisms, but was rather masked by the well-known taste of the sterilised milk.

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The bacteriological investigations of a rather indefinite flavour, which is largely masked in heated milk, cannot be very satisfactory, but it seems certain that microorganisms are not without influence in some direct or indirect way.

In the discussion that followed this paper (read before the Society of Chemical Industry), H. Droop Richmond, a well-known English chemist, said that he had for some years thought the taste complained of was not due to copper, because it was some time before it came out; he believed it

was due rather to microorganisms. The paper, however, showed that both were active agents. Mr. Richmond had succeeded in finding a liquefying microorganism which he had no doubt was similar to the one just shown by the authors. The metallic taste was found chiefly in winter, in milk that had been pasteurized; in summer it was not so marked, and neither was it so marked in the presence of a large number of lactic organisms. Mr. Richmond succeeded in getting rid of the taste by finding where the organisms existed.

There seems to be no doubt, therefore, that metallic flavor is caused by the direct absorption of metal by milk or cream. It is apparent also that more or less work has been done, the results of which, coinciding with some of the general observations noted in preceding pages, indicate that bacteria may cause the flavor.

NATURE OF MEDIUM HAVING METALLIC FLAVOR IN THE GREATEST DEGREE

The senses of taste and smell are the only means by which metallic flavor can be detected, and it is to be expected that the nature of the medium will influence these senses. It has already been stated that a high proportion of butterfat seems necessary for the production of metallic flavor, except in the case of buttermilk. Cream often showed only a trace of the flavor, but the flavor of buttermilk from the same cream churned in a glass bottle was very metallic. This showed that either the serum was more easily tasted than was the cream because of its physical nature, or else it was more metallic in flavor. The former is probably true, and the latter, according to work done and recorded later in this bulletin, is also true.

A few experiments were made in separating the water and the solids in buttermilk by centrifugal force. Buttermilk was put into a glass tube and placed in a centrifuge. After separation, the water and the solids were carefully examined in order to determine which had the more metallic flavor. No difference was noticed.

The metallic flavor appears to be volatile. In buttermilk that had developed the flavor in a glass bottle, the metallic odor was very noticeable immediately after the removal of the stopper. Several attempts were made to concentrate the flavor. Portions of the metallic buttermilk were distilled, and the distillate was then condensed by evaporation, but no metallic flavor was apparent. Instead the flavor was flat and oily.

It is difficult to explain why metallic flavor develops to a greater degree in buttermilk than in any other dairy product. As has already been stated, a high proportion of butterfat is generally essential for the production of metallic flavor, and ordinarily it does not develop in serum

alone, such as skimmed milk; but in buttermilk, which contains only a little more fat than does skimmed milk, the flavor becomes very pronounced. It was thought that there might be a relation between the acids of the butterfat and the metallic flavor. For example, some of these volatile acids might be in buttermilk and not in skimmed milk. Samples of butyric, caproic, caprylic, palmitic, stearic, and oleic acids were obtained, also propionic acid, which is lower in the fatty acid series, and succinic acid, which is a dibasic organic acid and may be found in dairy products. No sign of metallic flavor, however, could be detected in any of these acids.

FACTORS AFFECTING DEVELOPMENT OF METALLIC FLAVOR

RELATION OF FAT CONTENT TO METALLIC FLAVOR

Twenty-six samples of skimmed milk were placed in sterilized glass bottles and inoculated with buttermilk having metallic flavor. Only two of the samples showed any indication of metallic flavor, and in these the flavor could hardly be called metallic.

Forty-three samples of whole milk were treated in like manner. Only four developed metallic flavor, and in these the flavor was noticeable only in the cream on the surface.

Sixty-six samples of cream were inoculated with buttermilk having metallic flavor, and held in sterilized glass bottles. Seventeen of the sixty-six samples developed metallic flavor, a few of these being strongly metallic. In addition to the sixty-six samples, five samples of cream were allowed to stand at room temperature without inoculation. Four of these developed metallic flavor. The five samples were obtained from a source in which metallic flavor had previously appeared.

It has already been stated that metallic flavor has not been observed in cottage cheese, but that it is often very strong in soft cream cheese. It therefore seems apparent that the presence of fat in fairly large quantities is necessary for the flavor to develop.

RELATION OF ACIDITY TO METALLIC FLAVOR

Samples of buttermilk were placed in sterilized glass bottles and metallic flavor was allowed to develop. Of sixty-nine samples the acidity was noted in nineteen, and of these nineteen samples the acidity of six samples was taken both before and after the flavor became metallic. The results are shown in table 1.[2] The acidity of all the nineteen samples after metallic flavor developed varied from 0.69 to 0.83 per cent.

In many other samples of which no record was kept, it was possible to detect metallic flavor when the buttermilk became highly acid, and not until then.

[2] Tables referred to in this bulletin are printed in the appendix, pages 629 to 643.

TEMPERATURE IN RELATION TO METALLIC FLAVOR

It was thought that metallic flavor developed more rapidly at low temperatures — as, for example, in the refrigerator — than at room temperature. A series of experiments was conducted in order to determine this question. The results are given in table 2 (page 629).

The effects of different temperatures on the flavor varied but little. It is interesting to note, however, that some of the room-temperature samples showed a more pronounced metallic flavor than was found at the low temperatures, although probably the average of the low-temperature samples had a stronger flavor than the average of the room-temperature samples.

It is probable that other flavors develop at higher temperatures, which have a tendency to hide metallic flavor if it is present. However, if the product is tasted at the proper time, there is no doubt that metallic flavor will be found in no uncertain degree.

EFFECT OF COOKED FLAVOR IN RELATION TO METALLIC FLAVOR

As already noted (page 611), there is a difference of opinion regarding the effect of pasteurization on development of metallic flavor. In the course of this study several attempts were made to produce the flavor in pasteurized or sterilized cream, but since the cooked flavor masked most of the other flavors it was very difficult to reach any definite conclusion. One hundred and sixty-three attempts were made to produce metallic flavor in either sterilized or pasteurized cream, by inoculation with metallic-flavored buttermilk. In only two of the samples was the metallic flavor distinguished from the cooked flavor.

METHOD OF OBTAINING A MEDIUM FOR DETECTION OF METALLIC FLAVOR

In order to obtain a medium for detecting metallic flavor in dairy products, the common method of sterilization of cream by heat was first tried. Cream having a butterfat content of about 30 per cent was sterilized in the steam bath on three consecutive days, but the cooked flavor so masked the other flavors that this method could not be used. Lower temperatures were then tried. About 20 cubic centimeters of cream having a butterfat content of 30 per cent was put into test tubes. The wire container, with the tubes, was placed in water, and the temperature was raised to 140° F. and maintained at that point for twenty minutes. The process was repeated on three consecutive days. One hundred and three test tubes of this sterilized cream were then inoculated with metallic-flavored buttermilk; only two showed metallic flavor. In many cases the judges thought they could detect a slight metallic flavor or one similar

to it, but they were not certain, for the cooked flavor was present to a considerable degree.

Germicides were next considered, but nothing tasteless could be found. It was thought that volatile antiseptics might be used, such as ether or chloroform. Heat could then be applied to eliminate the antiseptics, but the physical properties of the cream were changed, this assuming a greasy appearance and an oily taste.

The only alternative seemed to be raw cream, and therefore milk was obtained directly from the cow. At first it was milked into large sterilized glass bottles and allowed to stand for twenty-four hours. At the end of that time the serum in the bottom of the bottles was drawn off with a sterilized pipette. Several trials were run, the cream being divided into portions of 50 cubic centimeters and put into smaller sterilized glass bottles. Each portion was inoculated with from one-half to one cubic centimeter of metallic-flavored buttermilk. Of twenty-three samples of this cream, eight developed metallic flavor.

Two objections to this method of separation became apparent. First, the cream was not sufficiently rich in butterfat, for it is not possible to obtain cream with a high fat content when the separation is done by any of the gravity methods. This high fat content is one of the essential conditions for the development of metallic flavor. Secondly, too much bacterial growth took place during the creaming process, which made the cream an uncertain medium for the study of the organisms that produce metallic flavor.

An attempt was next made to use cream from the market milk laboratory. This cream was standardized to a fat content of 32 per cent, and from this standpoint it was ideal. One hundred and seven samples of this cream were put into sterilized glass bottles. Each sample consisted of about 50 cubic centimeters of cream and was inoculated with from one-half to one cubic centimeter of metallic-flavored buttermilk. Thirty-nine of the samples showed metallic flavor. Two sets, of six samples each, were carefully tasted immediately after inoculation. Not a trace of metallic flavor could be detected. As additional evidence that this cream was not affected by contact with tin, it should be noted that not a check sample showed metallic flavor.

There was one factor in connection with the cream from the market milk laboratory that made it unsatisfactory: it contained a number of microorganisms which made interpretation of the results difficult. When metallic flavor was found in these samples, the question could well be asked, Was the flavor produced by organisms in the metallic-flavored buttermilk with which the cream was inoculated, or was there an associative action between the organisms in the buttermilk and those already in the cream?

In the search for better cream it was learned that the milk from a certain cow in the university herd usually showed the low bacteria count of from two to three hundred per cubic centimeter. In fact, the analysis of one milking showed only six bacteria per cubic centimeter. It was possible to hold the cream from this cow for about forty-eight hours at room temperature without much change. It therefore seemed that the associative action of the bacteria in the metallic-flavored buttermilk and in this cream would be almost negative. Therefore the remainder of the cream medium was obtained by taking milk from this cow, milking into a sterilized covered pail. The milk was taken immediately to the laboratory and separated in a sterilized separator, the cream being caught in sterilized glass bottles. As soon as the separation was complete, the cream was divided into portions of 50 cubic centimeters in sterilized glass bottles, and immediately inoculated.

BACTERIA IN SOME METALLIC-FLAVORED DAIRY PRODUCTS

The first series of samples to be examined for bacteria consisted of metallic-flavored butter. Five samples were plated in lactose agar and a brief morphological and cultural study was made, with the following results:

Sample 1. On one plate of the first sample there were twenty brown colonies in tetrads, and several milky white colonies. These organisms were micrococci. A few small acid colonies and one of *Oidium lactis* were found.

Sample 2. The second sample contained several spreaders, and one milky white colony with a regular edge which was a streptococcus. There were two chalky white colonies with very irregular edges and a wrinkled surface. These organisms were short, rod-shaped, and with rounded ends, and were nonmotile. Several small cream-colored punctiform colonies were present, which under the microscope appeared very much like *Oidium lactis* but were much smaller. Seventy-five *Oidium lactis* organisms were found.

Sample 3. In the third sample eight cream-colored colonies were found which were diplococci. There were two small brown colonies of staphylococci, and a few milky white colonies of bacteria which were nonmotile, short, and rod-shaped, with rounded ends.

Sample 4. In the fourth sample there were several small punctiform cream-colored colonies, three milky white colonies which were micrococci, and thirty colonies of *Oidium lactis*.

Sample 5. The one plate of the fifth sample that could be used contained only seven colonies. All were white and spreading, and the organisms were nonmotile, short, and rod-shaped.

No one organism was present in all the five samples. The organism that

was most abundant was *Oidium lactis*, but this was found in only three of the samples. To determine the effect of *Oidium lactis* in cream, six samples were inoculated with this organism; none of these developed metallic flavor.

Since it was possible to obtain metallic flavor almost at will in the buttermilk of the university laboratory, a study was made of the milk and cream delivered at one of the six receiving stations. A sample of each patron's milk or cream was put into a sterilized glass bottle. Room temperatures were used for incubation. The results are given in table 3 (page 630). It is seen from the table that two samples, one of cream (no. 21) and one of whole milk (no. 62), had metallic flavor. The flavor was stronger in the cream sample, and this was plated in order to determine whether or not the organism *Oidium lactis* was present — the idea having been suggested by Bouska (page 609) that *Oidium lactis* might be the cause of metallic flavor. A large number of colonies of *Oidium lactis* were found.

The results of a second study of the milk and cream at the same station are given in table 4 (page 631). Again sample 21 had metallic flavor, but sample 62 showed no trace of it. Another cream sample, however, no. 25, was metallic in flavor.

The impression is somewhat prevalent that cream of a high grade does not develop metallic flavor. It should be noted that in both studies sample 21 when fresh was judged as good. On the other hand, sample 62 was only fair in flavor when fresh, and soon turned to bad. Later four samples of cream, all of good flavor, were taken on different days from the patron who supplied sample 21. All these samples developed metallic flavor. It therefore seems that the flavor may develop in either good or poor cream.

In the experiment reported in table 4, an examination was made of all the samples for the presence of *Oidium lactis*. It is seen in the table that twenty of the thirty-two samples contained this organism. It should be noted, however, that the two samples which were metallic in flavor contained no *Oidium lactis*.

FORMALDEHYDE AND METALLIC FLAVOR

Formaldehyde is considered a very efficacious disinfectant. It kills not only bacteria, but also their enzymes. A study was made of the effect of formaldehyde on the development of metallic flavor in buttermilk. Samples of buttermilk that was not metallic in flavor were taken fresh from the churn and immediately treated with formalin (a solution containing from 37 to 40 per cent of formaldehyde). The results are shown in table 5 (page 632). It is seen from the table that in only a small proportion of the samples did metallic flavor not develop. Of the forty-one samples treated, thirty-five were metallic in flavor.

In order to determine the efficiency of the formalin a bacteriological examination was made, with rather surprising results. All the samples were incubated at room temperature for two days. On some of the plates there were many organisms. The results are shown in table 6 (page 633). These results indicate that formalin does not kill all the bacteria in buttermilk; it does, however, undoubtedly retard their growth.

EFFECT OF ADDING PURE LACTIC ACID TO SOME DAIRY PRODUCTS

Inasmuch as metallic flavor was developed in sterilized glass bottles in the presence of formalin, a substance that either kills or checks the growth of microorganisms and possibly checks enzymic growth, the question arose, What would be the effect of adding pure lactic acid to fresh buttermilk that is not metallic in flavor, or to skimmed milk? The reason for such a question was that a flavor of metallic nature might be produced by the action of the lactic acid and the serum of the buttermilk under certain conditions. Several experiments were run with varying quantities of pure lactic acid, but there was no trace of metallic flavor.

RELATION OF ENZYMIC GROWTH TO METALLIC FLAVOR

A limited study was made of the relation of enzymic growth to metallic flavor. The first problem in this connection was to find a solution that would effectually check the growth of the microorganisms and yet permit the enzymes to grow, and would not impart to the medium a flavor that would make detection of the metallic flavor difficult or impossible. No solution was found that left the metallic flavor clear and distinct. One compound, however, could be so managed as to make possible the detection of metallic flavor in at least a small number of samples.

Three per cent by measure of toluene was first used in buttermilk. Toluene is considered one of the most effective substances to check the growth of bacteria and still permit enzymic action, but the flavor is so sharp that detection of other flavors is impossible. The toluene could not be removed by heat, for its boiling point is 110° C. and if such a temperature were used the buttermilk would be scorched. Four unsuccessful attempts in the use of toluene were made.

The next agent to be tried was chloroform, which has a boiling point of 61.2° C. and can therefore be readily evaporated at a temperature that does not affect the flavor of buttermilk. According to Harding and Van Slyke (1907), 2.5 per cent of chloroform will check the growth of any microorganism in milk and not retard enzymic growth. In the experiments with chloroform, 50 cubic centimeters of fresh buttermilk,

not metallic in flavor, was placed in each of two sterilized glass bottles. One of these bottles was held as a check. In the other, 2.5 per cent by measure of chloroform was added. The mixture was then thoroughly shaken and kept at room temperature. The chloroform had a tendency to settle to the bottom; consequently it was necessary to shake the mixture several times in a day. At the end of two days about 20 cubic centimeters of the chloroformed buttermilk was put into a beaker and placed in water over a bunsen burner. The temperature of the water was maintained at from 62° to 65° C. until all the chloroform was evaporated. This process required about twenty minutes. Fourteen trials were made, in two of which a slight metallic flavor seemed to have developed. A sweetish flavor, resulting from the chloroform, always remained. In every case the check sample became metallic in flavor.

This study was not satisfactory, largely because of the difficulty in distinguishing the flavors after the buttermilk had been treated. Nevertheless, the indications were that metallic flavor might be produced by enzymic action.

NUMBER OF BACTERIA IN BUTTERMILK BEFORE AND AFTER DEVELOPMENT OF METALLIC FLAVOR

It was thought best, among other things, to determine the number of bacteria in the buttermilk before and after development of metallic flavor, for there were strong indications that the flavor might be caused by bacteria. Lactose agar and lactose gelatin were the media used. As has already been stated, high acidity seemed essential in the development of the flavor, and therefore media of different acid content were used. The regular lactose agar and lactose gelatin were prepared with an acidity of +1.5 (equivalent to 0.135 per cent lactic acid, which is a little lower than the acidity of sweet milk), and the other agar and gelatin were prepared with from 0.75 to 0.8 per cent of lactic acid (which is about the same as the acidity of the buttermilk that showed the strongest metallic flavor).

Much difficulty was experienced in preparing the agar and the gelatin with the high acidity of from 0.75 to 0.8 per cent. At first the acid was added in the same manner as in making the regular medium, but when the agar was sterilized it would not congeal. After several unsuccessful attempts the writer learned from Bouska (page 609) that the addition of tartaric acid before sterilization prevents solidification of the agar, but if the acid is added after sterilization it does not have this effect. This method was tried with the lactic acid, with satisfactory results.

The question of sterilization of the lactic acid solution was next considered, but on bacterial analysis it was found that the solution was already

sterile. The strength of this solution was nine-tenths of normal. When one cubic centimeter was placed in ten cubic centimeters of the agar or the gelatin, the percentage of lactic acid was from 0.75 to 0.8 per cent, depending on the age of the medium and therefore on the amount of evaporation that had taken place — it having been held for a part of the time at room temperature.

A study of table 7 (page 634), showing the number of bacteria in the buttermilk before and after metallic flavor developed, shows certain facts. First, there is no direct relationship between the number of bacteria and the metallic flavor, for in sample 1 only about 5,000,000 bacteria were found in the metallic-flavored buttermilk as against over 328,000,000 in sample 13. Secondly, there may be an increase or a decrease in the number of bacteria from the fresh to the metallic-flavored stage of the buttermilk; six samples show an increase and ten a decrease when grown on plain lactose agar, while in the high-acid agar three samples decreased in number of bacteria and eight increased. Thirdly, only a small proportion of the bacteria that grow in the lactose media with an acidity of +1.5 will grow on the lactose media with from 0.75 to 0.8 per cent of lactic acid.

It is seen in table 7 that eleven samples of buttermilk were plated on both agars at room temperature before and after the buttermilk became metallic in flavor. The ratios of the numbers of bacteria in these eleven samples in the two agars are shown in table 8 (page 635). Even though these ratios show a greater proportion of bacteria growing on the high-acid agar in the metallic-flavored buttermilk than in the fresh buttermilk, this does not seem particularly significant, for table 8 shows that there was great variation. Further, one would naturally expect to find a greater proportion of the bacteria producing metallic flavor growing on the high-acid medium, for metallic-flavored buttermilk, as already stated, is always high in lactic acid, and this of itself would tend to eliminate other bacteria that could not exist in a high-acid medium.

A QUALITATIVE STUDY OF THE BACTERIA IN FRESH AND IN METALLIC-FLAVORED BUTTERMILK

At the same time that the bacteria in the fresh and the metallic-flavored buttermilk were counted, a study was made of their action on litmus milk, which was prepared in the following manner: A litmus solution with an acidity of +1.5 was added to fresh skimmed milk at the rate of 1.5 cubic centimeters of litmus solution to 10 cubic centimeters of skimmed milk. After being thoroughly mixed, the litmus milk was put into sterilized test tubes, about 10 cubic centimeters in each tube. It was then

sterilized in the steam bath, by the intermittent method, on three consecutive days. The tubes were kept in the bath for thirty minutes each day.

The litmus milk was inoculated from the plates from which the counts were obtained as recorded in table 7. The inoculation consisted in transferring a part or the whole of an individual colony to a single tube of milk, the transfer being made with the end of a platinum needle pounded flat and bent in the form of a short hook. The number of tubes inoculated from one plate varied from 10 to 146, as seen in tables 9 and 10 (pages 636 and 637). The tubes were held at room temperature, and records were taken on the second, fifth, and fourteenth days after inoculation. The classes recorded were acid producing, acid producing with coagulation, peptonizers, alkaline, and inert.

If the group classed as peptonizers had appeared in larger numbers, it would have been necessary to hold the tubes longer than two weeks in order to give sufficient time for the peptonization process. But because of the probability that this group, which was very small, did not cause metallic flavor, the final record was taken on the fourteenth day.

The results of the study of the organisms transferred from agar of the lower acidity are shown in table 9 (page 636). The table shows that on the fourteenth day the average percentage of bacteria that produced acid and caused coagulation was 72.95. In the inert class there was an average percentage of 18.58, and in the group that showed acid production only there was an average percentage of 7.29.

Very different results appear in table 10 (page 637), which shows the bacterial action when a high-acid medium is used. The group showing acid production alone was much larger than for the normal medium, but in only one sample was there any coagulation, demonstrating that the bacteria which cause coagulation do not grow in a high-acid medium.

It is noticeable that the percentages of bacteria in all the groups as shown in both tables vary considerably. It is possible that in the case of the inert group some of the tubes were not inoculated. With the normal medium, however (table 9), the percentage of the inert group was small with the exception of two samples, leading to the conclusion that the number of unsuccessful transfers was small. Granting that all the tubes were properly inoculated, it is seen that in the high-acid agar on the fourteenth day an average of 56.79 per cent of the bacteria had not grown in litmus milk, while in the acid-producing group there was an average percentage of 38.93.

Because of the fact that metallic flavor was found only in dairy products of high acid content, it was natural to first study the group of bacteria that grew well on the high-acid medium and the group that would produce

acid. One set of twenty samples of cream was inoculated. The cream was examined when ripe, and the flavor was pronounced bitter. It did not resemble metallic flavor in the slightest degree.

The next bacteria to be studied were those of the group producing acid with coagulation. Twenty tubes were taken at random from about two hundred containing these bacteria. Samples of cream, each consisting of 20 cubic centimeters, were inoculated respectively with ½ cubic centimeter or less of the milk coagulum from each of the tubes. The samples of inoculated cream were held for thirty-six hours at room temperature, and were then placed in the refrigerator for another thirty-six hours before being judged.[3]

In the first trial of this experiment (table 11, page 638), three or more of the five judges pronounced thirteen of the twenty samples metallic in flavor. In the second trial (table 12, page 638), only two of the twenty samples were pronounced metallic in flavor by two of the three judges. In the third trial (table 13, page 639), three of the twenty samples were pronounced metallic in flavor by three of the four judges.

These results were not satisfactory, for there was considerable difference of opinion. In many cases there was a flavor which was somewhat similar to metallic flavor and yet could not be termed metallic. Some of the samples had seemingly passed through the metallic-flavored stage, and other flavors had developed which masked the metallic flavor.

Because of the difficulty in detecting the flavor, another trial was made. This time about 150 cubic centimeters of cream was used. All the samples were inoculated and ripened in the same manner as in the preceding trials. They were then churned by hand in the sample bottle in which the cream was ripened.

Eighteen of these twenty samples (table 14, page 639) were pronounced metallic in flavor by three or more of the five judges. The remaining two samples seemed to have the flavor to a very slight degree, but it was not sufficiently strong to warrant judging the samples as metallic-flavored. It should be noted, however, that sample 5 was in the first trial pronounced metallic in flavor by three of the five judges; and in the case of sample 7, in the first and fourth trials one judge pronounced the flavor metallic and another considered it doubtful, in the second trial the sample was pronounced metallic in flavor by the judge who raised a question about it in the first trial, and in the third trial two of the four judges placed it with the metallic-flavored samples. It would therefore seem that these samples also probably had metallic flavor in a slight degree.

[3] The judges were: H. L. Ayres, extension instructor, and instructor in butter making in the winter course, at Cornell University; H. W. Middaugh, superintendent of milk supply, formerly head butter maker; W. A. Luce, head butter maker; H. M. Pickerill, instructor in bacteriology, formerly assistant in the butter laboratory; and the writer.

A year after this work was done, a sample of buttermilk was obtained from the creamery laboratory and a study of the bacteria contained in it was made in the same manner as were the previous studies. Samples of cream were also obtained, in the manner described on page 619. About 150 cubic centimeters of cream was inoculated from a tube of the bacteria producing acid with coagulation. The cream was churned when ripe, and the flavor of the resulting buttermilk was studied.[4]

The results of the experiment (table 15, page 640) were peculiar and uncertain. In the first place, the check sample was pronounced metallic in flavor by all the five judges, while four of the sixteen inoculated samples showed no trace of metallic flavor. It must be remembered that the check sample was not sterile and could not be made sterile without affecting the flavor of the cream. Under such conditions it is to be expected that a check sample would occasionally show metallic flavor.

Another experiment was made with thirteen inoculated samples.[5] In this experiment the check sample was not metallic in flavor. Three of the inoculated samples (table 16, page 641) were pronounced metallic in flavor by four or more of the eight judges. With three exceptions, all the other samples were classed as metallic-flavored by at least one of the eight judges, and in the case of one of the exceptional samples four of the judges raised the question as to whether or not the flavor was metallic.

MORPHOLOGICAL CHARACTERISTICS

The bacteria in each culture were carefully studied under the microscope. They were found to be nonmotile, very short, and rod-shaped, appearing singly and in chains of two or more. A few of the chains contained seven or eight bacteria. They appeared to be the same as the well-known bacteria found in milk — the *Bacterium lactis acidi* group; if there was any difference it was in size, these appearing to be a little larger than those representative of the group, but the difference was slight.

CULTURAL CHARACTERISTICS

In all the tubes of litmus milk coagulation took place, and all samples showed growth without liquefaction on gelatin. These are the two cultural characters that have generally been used to identify members of the *Bacterium lactis acidi* group.

Further study of cultural characteristics seemed necessary. It has been usually considered that certain zymogenic bacteria can be more easily recognized by their growth on the various sugars and closely related sub-

[4] The judges were the same as in the earlier work, with the addition of Professor N. W. Hepburn, of the University of Illinois.

[5] Additional judges in this experiment were G. C. Supplee, assistant in the butter laboratory; and V. R. Jones, assistant in the testing laboratory.

stances than on any other media. Consequently a study was made of the bacteria on lactose, dextrose, saccharose, and raffinose, on the polysaccharide inulin, and on the alcohols mannite and glycerin. The nutrient solutions were prepared as by Rogers and Davis (1912), with the following proportions:

	Per cent
Beef extract	0.4
Peptone	1.0
Dibasic potassium phosphate	0.5
Test substance	2.0

In these experiments the age of the bacteria was not constant at the time of inoculation, for according to Rogers and Davis (1912) this is not necessary. They say (page 20 of reference cited): "In our own work no systematic investigation was undertaken to determine the constancy of the fermentation reactions, but all our observations tend to prove that the property of forming acid from carbohydrates and similar substances is not easily lost or acquired. One culture showing no evidence of ability to ferment saccharose was carried for one hundred generations, or a period of about one year, on a saccharose-agar. At the end of this period the culture still showed no fermentation of saccharose and the lactose fermentation remained unchanged."

Rogers and Davis consider that acid formation is the most important factor to be observed in the study of lactic acid bacteria. In these studies, however, the writer observed, along with the acid development, the appearance of the media and whether or not gas was produced.

The inverted-inner-tube method was used for the detection of gas. The cultures were incubated at room temperature for seven days. The acidity of the media was +1.5. The titration was made in duplicate with N/20 NaOH solution. The results of two studies of these bacteria when grown in the above solutions are given in tables 17 and 18 (pages 642 and 643). The percentage of samples that showed growth in the two tests are summarized in table 19 (page 643). These figures are very much like those reported by Rogers and Davis (1912), which they have assigned to the class generally known as the *Bacterium lactis acidi* group.

Further study should be made in order to determine the strain of the *Bacterium lactis acidi* group to which these organisms belong. A few attempts have been made to study the various strains of this group, but thus far very little has been accomplished.

CONCLUSIONS

Direct absorption of metals may cause metallic flavor in dairy products.

Bacteria may cause metallic flavor. Buttermilk in sterilized glass bottles developed the flavor in many cases. Of 241 samples of cream in

sterilized glass bottles, metallic flavor was produced in 79 by inoculation with metallic-flavored buttermilk; and of 157 samples of cream in sterilized glass bottles, which were inoculated with individual bacteria, 52 showed metallic flavor.

The organism that causes metallic flavor is a member or a strain of the *Bacterium lactis acidi* group.

Except in the case of buttermilk, a high fat content of the medium is essential for the production of metallic flavor.

Metallic flavor may develop in cream of either good or poor flavor.

The indications are that enzymes may be a factor in the production of metallic flavor.

High acidity of the medium is a necessary condition for development of metallic flavor.

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APPENDIX

TABLE 1. Acidity of Buttermilk Before and After Development of Metallic Flavor

Sample	Acidity before metallic flavor developed (per cent)	Acidity after metallic flavor developed (per cent)
1	0.67	0.73
2	0.64	0.74
3	0.67	0.81
4	0.67	0.74
5	0.67	0.75
6	0.67	0.72

TABLE 2. Effect of Temperature on Development of Metallic Flavor

Experiment	Number of samples metallic in flavor at low temperature	Number of samples metallic in flavor at room temperature	Remarks
1	1	1	Low-temperature sample more metallic in flavor than room-temperature sample
2	1	1	Low-temperature sample more metallic in flavor than room-temperature sample
3	1	1	Low-temperature sample more metallic in flavor than room-temperature sample
4	1	1	Low-temperature sample more metallic in flavor than room-temperature sample
5	1	1	Low-temperature sample more metallic in flavor than room-temperature sample
6	1	1	Room-temperature sample more metallic in flavor than low-temperature sample
7	1	1	Room-temperature sample more metallic in flavor than low-temperature sample
8	0	6	None of the six were metallic at low-temperature
9	4	3	Room-temperature sample more metallic in flavor than low-temperature sample

TABLE 3. A STUDY OF MILK AND CREAM AT ONE CORNELL UNIVERSITY STATION

Sample	Fresh		Age one day		Age two days		Age four days	
	Acidity (per cent)	Flavor	Flavor	Body	Flavor	Body	Flavor	Body
2	0.18	Good	Sour	Curdled, wheyey	Fair	Curdled, wheyey	Fair	Curdled, wheyey
5	0.19	Cowy, grassy	Bitter, stinking	Curdled, wheyey	Bad	Curdled, wheyey	Bad	Gassy
6	0.16	Good	Fair	Smooth curd	Fair	Smooth curd	Fair	Smooth curd
8	0.17	Good	Slightly sour	No curd	Good	Smooth curd	Fair	Smooth curd
11	0.18	Good	Fair	Smooth curd	Fair	Smooth curd	Good	Smooth curd
12	0.18	Grassy, a little off	Fair	Smooth curd	Fair	Smooth curd	Fair	Smooth curd
13	0.17	Fair	Fair	Smooth curd	Fair	Smooth curd	Bad	Smooth curd
14	0.18	Fair	Poor milk	Smooth curd	Fair	Smooth curd	Rotten	Smooth curd
15	0.20	Fair, grassy	Fair	Smooth curd	Fair	Smooth curd	Fair	Smooth curd
20*	0.30	Slightly sour	Sour, clean		Sour, clean		Fair	
21*	0.38	Slightly sour, good	Sour, good		Sour		**Metallic**	
25a*	0.21	Watery, sour, poor	Flat, watery, sour		Watery		Watery	
25b*	0.44	Fair, sour	Sour		Sour		Sour, fair	
27	0.16	Fair	Bad	No curd	Bad	Slightly curded	Rotten	
28	0.17	Fair	Bad	Smooth curd	Bad	Smooth curd	Fair	Gassy
32*	0.41	Grassy, bad	Bad		Fair		Fair	
33	0.19	Good	Fair	Smooth curd	Fair	Smooth curd	Fair	
34	0.17	Fair	Bad	No curd	Bad	Slightly curded	Bad	
35	0.14	Good	Good	Smooth curd	Bad	Smooth curd	Fair	Smooth curd
36	0.18	Good	Bad	Gassy curd	Bad	Gassy	Bad	Gassy
38		Fair	Bad	No curd	Bad	Slightly curded	Bad	
39*	0.38	Grassy	Bitter, bad		Bad		Old, bad	
40	0.14	Good	Fair	Gassy	Bad	Gassy	Fair	
42	0.16	Fair	Bad	Gassy	Bad	Gassy	Bad	Gassy
44	0.17	Good	Bad	No curd	Bad	Slightly curded	Bad	Gassy
46	0.22	Fair	Fair	Slightly curded	Bad		Fair	
48	0.20	Good	Good	Smooth curd	Fair	Smooth curd	Fair	
50	0.18	Fine	Sweetish	Wheyed off	Fair		Fair	
52*	0.17	Fair	Fair		Poor		Bad	
55	0.17	Good	Fair	Smooth curd	Bad		Bad	
56	0.16	Fair	Bad	Smooth curd	Bad		Bad	
57	0.21	Good	Fair	Smooth curd	Bad		Bad	
60	0.18	Good	Fair	Smooth curd	Fair		Bad	
61	0.18	Fair	Fair	Smooth curd	Bad		Bad	
62	0.19	Fair	Bad	Smooth curd	**Metallic**		Bad	
63	0.17	Fair	Bad	Smooth curd	Bad		Bad	

*Cream.

TABLE 4. A STUDY OF MILK AND CREAM AT ONE CORNELL UNIVERSITY STATION

Sample	Flavor		Oidium lactis
	When fresh	When one day old	
5	Good	Bad	—
6	Good	Fair	—
7	Fair	Bad	+
8	Good	Fair	+
11	Good	Fair	—
12	Good	Bad	+
13	Good	Fair	+
14	Good	Fair	+
16	Good	Bad	—
21*	Good	Slightly metallic	—
25*	Fair	Slightly metallic	—
27	Fair	Fair	+
28	Good	Cheesy	+
32*	Fair	Fair	+
33	Good	Bad	+
36	Bad	Cheesy	+
39*	Bad	Bad	+
40	Fair	Fair	—
42	Good	Bad	+
44	Fair	Fair	—
46	Fair	Good	+
48	Fair	Fair	+
49	Fair	Fair	+
50	Fair	Rotten	—
52*	Good	Fair	—
55	Good	Fair	+
56	Fair	Bad	—
57	Fair	Fair	—
60	Good	Good	+
61	Good	Good	+
62	Fair	Fair	+
63	Good	Bad	+

* Cream.

TABLE 5. EFFECT OF FORMALDEHYDE ON METALLIC FLAVOR IN BUTTERMILK

Experiment	Sample	Buttermilk (cubic centimeters)	Formalin (drops)	Age (days)	Flavor
I	1	100	2	1	Metallic
	2	100	4	1	Metallic
II	1	100	1	1	Metallic
	2	100	2	1	Metallic
	3	100	4	1	Metallic
	4	100	8	1	Metallic
III	1	100	2	1	Metallic
	2	100	4	1	Metallic
IV	1	100	2	2	Metallic
	2	100	4	2	Metallic
	3	100	6	2	Metallic
	4	100	8	2	Metallic
	5	100	10	2	Metallic
	6	100	12	2	Metallic
V	1	100	3	2	Metallic
	2	100	6	2	Not metallic
	3	100	9	2	Not metallic
	4	100	12	2	Not metallic
	5	100	15	2	Metallic
VI	1	100	5	2	Metallic
	2	100	10	2	Metallic
	3	100	15	2	Metallic
	4	100	20	2	Too much formalin
	5	100	25	2	Too much formalin
	6	100	30	2	Too much formalin
VII	1	100	2	2	Metallic
	2	100	4	2	Metallic
	3	100	6	2	Metallic
	4	100	8	2	Metallic
VIII	1	100	1	2	Metallic
	2	100	2	2	Metallic
	3	100	3	2	Metallic
	4	100	4	2	Metallic
	5	100	5	2	Metallic
	6	100	6	2	Metallic
IX	1	100	1	2	Metallic
	2	100	2	2	Metallic
	3	100	3	2	Metallic
	4	100	4	2	Metallic
	5	100	5	2	Metallic
	6	100	6	2	Metallic

TABLE 6. EFFECT OF FORMALDEHYDE ON BACTERIA IN BUTTERMILK

Experiment	Sample	Buttermilk (cubic centimeters)	Formalin (drops)	Bacteria per loop	Flavor
V.	1	100	3	90	Metallic
	2	100	6	60	Not metallic
	3	100	9	20	Not metallic
	4	100	12	15	Not metallic
	5	100	15	18	Metallic
VI.	1	100	5	520	Metallic
	2	100	10	250	Metallic
	3	100	15	150	Metallic
	4	100	20	100	Too much formalin
	5	100	25	75	Too much formalin
	6	100	30	75	Too much formalin

TABLE 7. NUMBER OF BACTERIA IN BUTTERMILK BEFORE AND AFTER DEVELOPMENT OF METALLIC FLAVOR

Sample	Fresh buttermilk, not metallic in flavor				Buttermilk metallic in flavor at room temperature			
	Agar	High-acid agar	Gelatin	High-acid gelatin	Agar	High-acid agar	Gelatin	High-acid gelatin
1	2,031,250	...	...	...	4,656,250	...	...	...
2	72,000,000	...	...	...	50,000,000	...	...	...
3	96,755,000	6,300	...	...	159,500,000	17,225	...	...
4	73,000,000	1,133	...	...	77,750,000	1,700	...	...
5	916,600	...	...	...	21,312,500	...	...	...
6	184,000,000	2,075	...	...	207,250,000	18,800	...	...
7	233,750,000	17,800	...	...	129,375,000	16,650	...	...
8	310,000,000	1,575	...	...	246,500,000	1,462	...	...
9	194,500,000	3,800	...	...	15,050,000	5,787	...	...
10	120,500,000	212	...	...	158,083,000	650	...	...
11	147,000,000	987	...	...	126,500,000	4,250	...	...
12	175,500,000	733	319,830,000	3,116	63,625,000	42,200	60,916,000	2,669
13	366,500,000	1,516	...	7,825	328,750,000	1,175	294,000,000	85,200
14	206,600,000	1,987	285,750,000	4,462	187,500,000	4,016	...	7,730
15	232,000,000	...	...	...	101,666,000	...	...	...
16	165,500,000	...	...	...	64,625,000	...	...	...
17	...	...	...	...	339,300,000	...	...	...
					Buttermilk metallic in flavor at 50° F. or lower temperature			
11	147,000,000	987	...	...	127,500,000	616	...	...
12	175,500,000	733	319,830,000	3,116	68,750,000	287	189,250,000	3,150
13	366,500,000	1,516	...	7,825	200,500,000	2,900	129,750,000	66,250
14	206,600,000	1,987	285,750,000	4,462	136,930,000	7,388	...	7,380

TABLE 8. RATIOS OF NUMBERS OF BACTERIA IN THE HIGH-ACID AGAR AND IN THE NORMAL AGAR

Sample	Buttermilk not metallic in flavor		Buttermilk metallic in flavor	
	High-acid agar	Normal agar	High-acid agar	Normal agar
3	1	to 15,358	1	to 9,260
4	1	to 64,431	1	to 45,735
6	1	to 88,675	1	to 11,024
7	1	to 13,132	1	to 7,770
8	1	to 196,825	1	to 168,605
9	1	to 51,184	1	to 2,601
10	1	to 568,396	1	to 243,205
11	1	to 148,936	1	to 29,765
12	1	to 239,427	1	to 1,508
13	1	to 241,755	1	to 279,787
14	1	to 103,976	1	to 46,688
Average	1	to 55,305	1	to 14,922

TABLE 9. ACTION OF BACTERIA FROM FRESH AND FROM METALLIC-FLAVORED BUTTERMILK ON LITMUS MILK*

Sample†	Number of test tubes of litmus milk	Age two days					Age five days					Age fourteen days				
		Acid producing (per cent)	Acid producing with coagulation (per cent)	Peptonizers (per cent)	Alkaline (per cent)	Inert (per cent)	Acid producing (per cent)	Acid producing with coagulation (per cent)	Peptonizers (per cent)	Alkaline (per cent)	Inert (per cent)	Acid producing (per cent)	Acid producing with coagulation (per cent)	Peptonizers (per cent)	Alkaline (per cent)	Inert (per cent)
1 a.....	143	84.60	0	0	1.39	1.32	24.40	72.00	0	13.90	2.09	9.80	86.01	0	1.39	2.79
1 b.....	131	61.20	0	0	0	38.70	22.90	71.75	0	0	5.40	20.61	74.80	0	0	4.58
2 a.....	130	89.20	0	0	0.76	10.00	1.53	93.84	0	1.53	3.06	1.53	93.84	0	1.53	3.06
2 b.....	54	83.30	0	0	0	16.60	1.85	92.59	0	1.85	3.70	1.85	92.59	18.50	1.85	1.85
5 a.....	81	97.50	0	0	0	2.50	3.70	93.82	0	0	2.47	2.47	95.00	0	0	2.47
6 a.....	76	......	......	......	......	......	21.05	25.00	0	0	53.90	10.50	40.80	1.31	0	47.30
6 b.....	47	......	......	......	......	......	4.25	19.15	0	0	76.50	4.25	27.60	0	0	68.00

* Samples plated on lactose agar having an acidity of +1.5.
† a, Buttermilk before development of metallic flavor; b, buttermilk after development of metallic flavor.

TABLE 10. Action of Bacteria from Fresh and from Metallic-flavored Buttermilk on Litmus Milk*

Sample†	Number of test tubes of litmus milk	Age two days: Acid producing (per cent)	Age two days: Acid producing with coagulation (per cent)	Age two days: Peptonizers (per cent)	Age two days: Alkaline (per cent)	Age two days: Inert (per cent)	Age five days: Acid producing (per cent)	Age five days: Acid producing with coagulation (per cent)	Age five days: Peptonizers (per cent)	Age five days: Alkaline (per cent)	Age five days: Inert (per cent)	Age fourteen days: Acid producing (per cent)	Age fourteen days: Acid producing with coagulation (per cent)	Age fourteen days: Peptonizers (per cent)	Age fourteen days: Alkaline (per cent)	Age fourteen days: Inert (per cent)
3 x	146	......	......	......	......	......	92.46	0	0	0	7.54	93.10	0	0	0	6.90
3 y	129	......	......	......	......	......	75.20	0	0	0	24.80	81.40	0	0	0	18.50
4 x	52	......	......	......	......	......	19.23	0	0	0	80.70	21.10	0	0	0	71.10
4 y	40	......	......	......	......	......	35.00	0	0	0	65.00	37.20	0	0	0	52.50
6 x	112	16.90	0	0	0	83.10	22.30	0	0	0	77.60	22.30	0	1.78	0.89	75.00
6 y	115	32.10	0	0.86	0	66.90	32.10	0	0.86	0	66.90	34.90	0	0.86	0.86	62.60
7 x	96	82.30	0	0	0	17.70	86.30	0	0	0	13.70	86.30	0	0	31.20	10.30
7 y	88	79.50	0	0	0	20.50	81.80	2.20	0	0	15.80	80.60	3.4	1.10	0	14.70
8 x	66	36.40	0	0	0	63.60	41.00	0	0	0	59.00	37.80	0	3.03	6.06	53.00
8 y	63	31.90	0	0	0	68.10	39.60	0	0	0	60.40	38.00	0	0	1.60	60.30
9 x	66	63.60	0	0	0	36.40	......	......	......	......	......	74.20	9	0	0	25.80
9 y	83	......	......	......	......	......	......	......	......	......	......	85.50	0	0	1.20	13.20
10 x	10	......	......	......	......	......	......	......	......	......	......	5.00	0	0	0	95.00
10 y	58	......	......	......	......	......	22.40	0	0	0	75.60	32.70	0	3.45	3.45	60.30
11 y	37	......	......	......	......	......	......	......	......	......	......	21.60	0	5.40	0	72.90
11 z	29	......	......	......	......	......	......	......	......	......	......	13.80	0	6.90	0	79.30
12 x	41	......	......	......	......	......	......	......	......	......	......	2.43	0	0	7.29	90.24
12 z	19	......	......	......	......	......	......	......	......	......	......	0	0	0	0	100.00
13 x	33	......	......	......	......	......	......	......	......	......	......	9.09	0	0	0	90.90
13 z	60	......	......	......	......	......	......	......	......	......	......	1.50	0	16.60	0	83.30

* Samples plated on lactose agar having an acidity of from 0.75 to 0.80 per cent.

† x, Fresh buttermilk; y, buttermilk after development of metallic flavor; z, buttermilk in which metallic flavor developed at low temperature in the refrigerator.

TABLE 11. PRODUCTION OF METALLIC FLAVOR BY INOCULATION

Sample	Judged by				
	Ayres	Middaugh	Pickerill	Luce	Guthrie
1	Slightly metallic.	Metallic	No	Metallic	Slightly metallic
2	No	Metallic	No	No	No
3	No	No	No	No	No
4	Metallic	Metallic	Slightly metallic.	Slightly metallic.	No
5	Metallic	Metallic	No	No	Slightly metallic
6	No	Metallic	No	Slightly metallic.	Slightly metallic
7	No	Slightly metallic.	No	Doubtful	No
8	No	Metallic	No	Metallic	No
9	Metallic	Metallic	No	Slightly metallic.	Slightly metallic
10	No	Metallic	No	Metallic	No
11	Strongly metallic	Slightly metallic.	No	Slightly metallic.	Metallic
12	No	Metallic	No	Slightly metallic.	Slightly metallic
13	No	Metallic	Slightly metallic.	No	Slightly metallic
14	Metallic	Metallic	Slightly metallic.	Strongly metallic	Slightly metallic
15	Metallic	Metallic	Slightly metallic.	Metallic	Slightly metallic
16	No	Metallic	No	Slightly metallic.	Slightly metallic
17	Doubtful	Metallic	Doubtful	Slightly metallic.	No
18	No	Slightly metallic.	No	Doubtful	No
19	Strongly metallic	Metallic	Slightly metallic.	Metallic	Slightly metallic
20	Slightly metallic.	Doubtful	Doubtful	Metallic	Slightly metallic
Check	No	No	No	No	No

TABLE 12. PRODUCTION OF METALLIC FLAVOR BY INOCULATION

Sample	Judged by				
	Ayres	Middaugh	Pickerill	Luce	Guthrie
1	No	No report	No report	Slightly metallic	Slightly metallic
2	No	No report	No report	No	No
3	No	No report	No report	No	No
4	No	No report	No report	Metallic	No
5	No	No report	No report	Metallic	No
6	No	No report	No report	Doubtful	No
7	No	No report	No report	Metallic	No
8	No	No report	No report	Slightly metallic	No
9	No	No report	No report	Slightly metallic	Slightly metallic
10	No	No report	No report	No	No
11	No	No report	No report	Metallic	No
12	No	No report	No report	No	Slightly metallic
13	No	No report	No report	No	No
14	No	No report	No report	Slightly metallic	No
15	No	No report	No report	Slightly metallic	No
16	No	No report	No report	Metallic	No
17	No	No report	No report	No	No
18	No	No report	No report	Metallic	No
19	No	No report	No report	No	No
20	No	No report	No report	No	No
Check	No	No report	No report	No	No

TABLE 13. PRODUCTION OF METALLIC FLAVOR BY INOCULATION

Sample	Judged by				
	Ayres	Middaugh	Pickerill	Luce	Guthrie
1	No	Metallic	No report	Metallic	No
2	No	Metallic	No report	Metallic	No
3	No	Metallic	No report	Strongly metallic	No
4	No	Metallic	No report	Metallic	No
5	No	Strongly metallic	No report	Strongly metallic	No
6	No	Metallic	No report	Slightly metallic	No
7	No	Metallic	No report	Metallic	No
8	No	Metallic	No report	Strongly metallic	No
9	No	Metallic	No report	Slightly metallic	Slightly metallic
10	No	Metallic	No report	Metallic	Slightly metallic
11	No	Metallic	No report	Metallic	No
12	No	Strongly metallic	No report	Metallic	No
13	No	Metallic	No report	Metallic	Slightly metallic
14	No	Metallic	No report	Slightly metallic	No
15	No	Metallic	No report	Strongly metallic	No
16	No	No	No report	Metallic	No
17	No	Metallic	No report	Slightly metallic	No
18	No	No	No report	Slightly metallic	No
19	No	Doubtful	No report	Slightly metallic	Doubtful
20	No	Slightly metallic	No report	Metallic	No
Check	No	No	No report	No	No

TABLE 14. PRODUCTION OF METALLIC FLAVOR BY INOCULATION

Sample	Judged by				
	Ayres	Middaugh	Pickerill	Luce	Guthrie
1	Metallic	Metallic	Metallic	Strongly metallic	Metallic
2	Metallic	Metallic	Doubtful	Metallic	Metallic
3	Metallic	Metallic	Metallic	Metallic	Slightly metallic
4	Metallic	Metallic	Bitter	Metallic	Slightly metallic
5	Doubtful	Metallic	No	No	No
6	Metallic	Metallic	Bitter metallic	Strongly metallic	Metallic
7	No	Slightly metallic	No	Doubtful	No
8	No	Metallic	Metallic	Metallic	Very metallic
9	Metallic	Metallic	No	Strongly metallic	Slightly metallic
10	No	Metallic	Slightly metallic	Metallic	Metallic
11	Metallic	Metallic	No	Metallic	Slightly metallic
12	Metallic	Metallic	Doubtful	Strongly metallic	Metallic
13	Metallic	Metallic	Slightly metallic	Metallic	Metallic
14	Metallic	Metallic	Metallic	Metallic	Slightly metallic
15	Metallic	Metallic	No	Metallic	Metallic
16	Metallic	Metallic	Doubtful	Metallic	Metallic
17	Metallic	Metallic	Slightly metallic	Slightly metallic	Slightly metallic
18	Doubtful	Metallic	Metallic	Metallic	Metallic
19	Slightly metallic	Metallic	No	Slightly metallic	Slightly metallic
20	Metallic	Metallic	Metallic	Metallic	Metallic
Check	No	No	No	No	No

TABLE 15. PRODUCTION OF METALLIC FLAVOR BY INOCULATION

Sample	Judged by				
	Hepburn	Ayres	Pickerill	Luce	Guthrie
1	Metallic	Metallic	Slightly metallic.	Slightly metallic.	Slightly metallic
2	No	No	No	No	Doubtful
3	Metallic	Metallic	No, high acid	Strongly metallic	Metallic
4	Metallic	Strongly metallic	Strongly metallic	Strongly metallic	Strongly metallic
5	Metallic	Doubtful	Metallic, high acid	Slightly metallic.	Slightly metallic, overripe
6	No	Slightly metallic.	Slightly metallic.	Metallic	Slightly metallic
7	Strongly metallic	Doubtful	Slightly metallic.	Slightly metallic.	No, overripe
8	Metallic	No	Slightly metallic.	Slightly metallic.	Doubtful
9	Metallic	No, high acid	Metallic	Slightly metallic.	Slightly metallic
10	Slightly metallic.	No	Slightly metallic.	Metallic	Metallic
11	Strongly metallic	No	No	Metallic	Metallic
12	No	No	Metallic	Slightly metallic.	Slightly metallic
13	Strongly metallic	Slightly metallic, high acid	Metallic	Slightly metallic.	Slightly metallic
14	No	High acid, no	No	Doubtful	No, overripe
15	No	No	No	No	No, overripe
16	No	No	No	No	No, overripe
Check	Metallic	Metallic	Metallic	Strongly metallic	Metallic

TABLE 16. PRODUCTION OF METALLIC FLAVOR BY INOCULATION

Sample	Judged by							
	Hepburn	Ayres	Pickrill	Luce	Middaugh	Supplee	Jones	Guthrie
1	Slightly metallic	No	No	Metallic	No	No	No	Slightly metallic
2	Metallic	No	No	No	No, high acid	No	No	Metallic
3	No	No	No	Slightly metallic	Doubtful	Metallic	No	No
4	No	No	Slightly metallic	No	No	No	No	No
5	Slightly metallic	Metallic	Metallic	Strongly metallic	Metallic	Metallic	Strongly metallic	Metallic
6	Slightly metallic	No	No	No	No	No	No	No
7	No	No	No	No	No	Slightly metallic	No	No
8	Doubtful	No	No	Doubtful	No	Doubtful	No	Doubtful
9	Metallic	Slightly metallic	Slightly metallic	Strongly metallic	Metallic	Strongly metallic	Metallic	Slightly metallic
10	Slightly metallic	No	No	Metallic	Slightly metallic	Slightly metallic	No	No
11	No	No	No	No	No	No	No	No
12	No	No	Slightly metallic	No	No	Metallic	Slightly metallic	No
13	No	No	No	No	No	No	No	No
Check	No	No	No	No	No	No	No	No

TABLE 17. Some Cultural Characteristics of Twenty Microorganisms

Sample	Gas formation	Milk curdled	Gelatin liquefied	Lactose: Cloudiness	Lactose: Percentage of acidity	Lactose: Sediment	Dextrose: Cloudiness	Dextrose: Percentage of acidity	Dextrose: Sediment	Saccharose: Cloudiness	Saccharose: Percentage of acidity	Saccharose: Sediment
1	—	+	—	+	0.79*	+	+	0.64	—	—	0.12	—
2	—	+	—	—	0.79	+	+	0.61	+	—	0.10	—
3	—	+	—	—	0.77	+†	+	0.59*	+	+	0.81	+
4	—	+	—	—	0.79	+	+	0.63	+	—	0.14	—
5	—	+	—	—	0.77	+	+	0.64	+	+	0.82	+
6	—	+	—	—	0.73	+	+	0.63	+	+	0.10	+
7	—	+	—	—	0.81	+	+	0.64	+	—	0.14	—
8	—	+	—	—	0.77	+	+	0.63	+	—	0.12	—
9	—	+	—	—	0.79	+	+	0.61	+	+	0.72	+
10	—	+	—	—	0.84	+	+	0.63	+	—	0.14	—
11	—	+	—	—	0.77	+	+	0.64	+	—	0.14	—
12	—	+	—	—	0.79	+	+	0.59	+	—	0.10	—
13	—	+	—	—	0.81	+	+	0.61	+	+	0.16	+
14	—	+	—	—	0.82	+	+	0.68	+	—	0.12	—
15	—	+	—	—	0.77	+	+	0.63	+	—	0.14	—
16	—	+	—	—	0.81	+	+	0.63	+	—	0.10	—
17	—	+	—	—	0.70	+	+	0.63	+	—	0.14	—
18	—	+	—	—	0.77*	+	+	0.63	+	+	0.50	+
19	—	+	—	—	0.81	+	+	0.61	+	—	0.10	—
20	—	+	—	—	0.79	+	+	0.64	+	+	0.12	+
Check	—	—	—	—	0.18	—	—	0.19	—	—	0.10	—

Sample	Glycerin: Cloudiness	Glycerin: Percentage of acidity	Glycerin: Sediment	Mannite: Cloudiness	Mannite: Percentage of acidity	Mannite: Sediment	Raffinose: Cloudiness	Raffinose: Percentage of acidity	Raffinose: Sediment	Galactose: Cloudiness	Galactose: Percentage of acidity	Galactose: Sediment	Inulin: Cloudiness	Inulin: Percentage of acidity	Inulin: Sediment‡
1	—	0.12	—	—	0.12	—	—	0.14	—	+	0.88	+	—	0.10	—
2	—	0.10	—	—	0.12	—	—	0.10	—	+	0.70	+	—	0.12	—
3	—	0.12*	—	—	0.12*	—	+	0.54*	—	+	0.73*	+	—	0.14	—
4	+	0.10	—	—	0.12	—	—	0.12	—	+	0.59	+	—	0.12	—
5	—	0.10	—	—	0.19	—	—	0.12	—	+	0.81	+	—	0.12	—
6	—	0.10	—	—	0.12	—	—	0.12	—	+	0.82	+	—	0.12	—
7	—	0.10	—	—	0.12	—	—	0.14	—	+	0.82	+	—	0.10	—
8	—	0.12	—	—	0.09	—	—	0.12	—	+	0.82	+	—	0.10	—
9	—	0.10	—	—	0.09	—	—	0.12	—	+	0.86	+	—	0.12	—
10	—	0.10	—	+	0.48	—	—	0.10	—	+	0.84	+	—	0.14	—
11	+	0.10	—	—	0.09	—	—	0.10	—	+	0.86	+	—	0.12	—
12	+	0.12	—	—	0.10	—	—	0.12	—	+	0.81	+	—	0.12	—
13	—	0.12	—	—	0.10	—	—	0.10	—	+	0.84	+	—	0.12	—
14	—	0.12	—	—	0.12	—	—	0.10	—	+	0.81	+	—	0.12	—
15	—	0.12	—	—	0.12	—	—	0.12	—	+	0.81	+	—	0.10	—
16	—	0.12	—	—	0.12	—	—	0.12	—	+	0.86	+	—	0.12	—
17	—	0.12	—	+	0.25	—	—	0.12	—	+	0.84	+	—	†	—
18	—	0.10	—	—	....	—	+	0.57*	—	+	0.70*	+	—	*	—
19	—	0.10	—	—	0.12	—	—	0.10	—	+	0.84	+	—	0.12	—
20	—	0.12	—	—	0.12	—	—	0.10	—	+	0.86	+	—	0.12	—
Check	—	....	—	—	0.12	—	—	0.10	—	—	0.27	—	—	0.12	—

* Mold.
† Terminal ring.
‡ A white precipitate formed in the inulin when it was sterilized.

+, Yes.
—, No.

TABLE 18. SOME CULTURAL CHARACTERISTICS OF TWENTY MICROORGANISMS

Sample	Gas formation	Milk curdled	Gelatin liquefied	Lactose: Cloudiness	Lactose: Percentage of acidity	Lactose: Sediment	Dextrose: Cloudiness	Dextrose: Percentage of acidity	Dextrose: Sediment	Saccharose: Cloudiness	Saccharose: Percentage of acidity	Saccharose: Sediment	Glycerin: Cloudiness	Glycerin: Percentage of acidity	Glycerin: Sediment	Mannite: Cloudiness	Mannite: Percentage of acidity	Mannite: Sediment	Raffinose: Cloudiness	Raffinose: Percentage of acidity	Raffinose: Sediment	Galactose: Cloudiness	Galactose: Percentage of acidity	Galactose: Sediment	Inulin: Cloudiness	Inulin: Percentage of acidity	Inulin: Sediment‡
1	—	+	—	—	0.73	+	—	0.73	+	—	0.17	—	—	0.15	—	—	0.13	—	—	0.10	—	+	0.66	+	—	0.13	—
2	—	+	—	—	0.68	+	—	0.75	+	—	0.13	—	—	0.14	—	—	0.14	—	—	0.12	—	+	0.70	+	—	0.17	—
3	—	+	—	—	0.70	+	—	0.77	+	—	0.14	—	—	0.13	—	—	0.20	—	—	0.18	—	+	0.67	+	—	0.15	—
4	—	+	—	—	0.84	+	—	0.79	+	—	0.13	—	—	0.15	—	—	0.12	—	—	0.10	—	+	0.73	+	—	0.18	—
5	—	+	—	—	0.82	+	—	0.81	+	—	0.14	—	—	0.14	—	—	0.13	—	—	0.12	—	+	0.72	+	—	0.16	—
6	—	+	—	—	0.84	+	—	0.77	+	—	0.14	—	—	0.14	—	—	0.14	—	—	0.18	—	+	0.61	+	—	0.21	—
7	—	+	—	—	0.84	+	—	0.77	+	—	0.17	—	—	0.13	—	—	0.13	—	—	0.16	—	+	0.70	+	—	0.15	—
8	—	+	—	—	0.66	+	—	0.77	+	—	0.12	—	—	0.14	—	—	0.15	—	—	0.15	—	+	0.57†	+	—	0.15	—
9	—	+	—	—	0.66	+	—	0.75	+	+	0.66	—	—	0.14	—	—	0.15	—	—	0.15	—	+	0.57	+	—	0.14	—
10	—	+	—	—	0.72	+	—	0.77	+	—	0.14	—	—	0.14	—	—	0.16	—	—	0.15	—	+	0.70	+	—	0.16	—
11	—	+	—	—	0.68	+	—	0.84	+	—	0.13	—	—	0.17	—	—	0.13	—	—	0.17	—	+	0.56	+	—	0.15	—
12	—	+	—	—	0.70	+	+	0.75	+	—	0.16	—	—	0.14	—	—	0.16	—	—	0.16	—	+	0.59	+	—	0.16	—
13	—	+	—	—	0.72	+	—	0.79	+	—	0.15	—	—	0.14	—	—	0.14	—	—	0.15	—	+	0.65	+	—	0.17	—
14	—	+	—	—	0.66	+	—	0.75	+	—	0.13	—	—	0.15	—	—	0.14	—	—	0.09	—	+	0.59	+	—	0.18	—
15	—	+	—	—	0.72	+	—	0.75	+	—	0.14	—	—	0.16	—	—	0.23	—	—	0.09	—	+	0.57	+	—	0.17	—
16	—	+	—	—	0.73	+	—	0.79	+	—	0.13	—	—	0.13	—	—	0.17	—	—	0.10	—	+	0.22	+	—	0.15	—
17	—	+	—	—	0.72	+	—	0.75	+	—	0.13	—	—	0.15	—	—	0.14	—	—	0.16	—	+	0.70	+	—	0.13	—
18	—	+	—	—	0.63*	+	—	0.75*	+	—	0.46*	—	—	0.15*	—	—	0.35*	—	—	0.47*	—	+	0.70	+	—	0.13*	—
19	—	+	—	—	0.72	+	—	0.79	+	—	0.16	—	—	0.16	—	—	0.29	—	—	0.18	—	+	0.71	+	—	0.15	—
20	—	+	—	—	0.72	+	—	0.70	+	—	0.14	—	—	0.13	—	+	0.40	—	—	0.16	—	+	0.70	+	—	0.14	—
Check	—	—	—	—	0.25	+	—	0.19	—	—	0.15	—	—	0.13	—	—	0.13	—	—	0.16	—	—	....	—	—	0.16	—

* Mold.
† Terminal ring.
‡ A white precipitate formed in the inulin when it was sterilized.

+, Yes.
—, No.

TABLE 19. PERCENTAGE OF SAMPLES SHOWING GROWTH IN TABLES 17 AND 18

Table	Lactose	Dextrose	Saccharose	Glycerin	Mannite	Raffinose	Galactose	Inulin
17	100	100	20	0	10	0	100	0
18	100	100	5	0	20	0	100	5

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AGRICULTURAL EXPERIMENT STATION OF THE
NEW YORK STATE COLLEGE OF AGRICULTURE

BEVERLY T. GALLOWAY, Director

Department of Forestry

REFORESTING METHODS AND RESULTS OF FOREST PLANTING IN NEW YORK STATE

BY B. H. PAUL

PLANTATION MADE BY THE NEW YORK STATE COLLEGE OF FORESTRY AT CORNELL UNIVERSITY IN 1899

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CONTENTS

REFORESTING METHODS AND RESULTS OF FOREST PLANTING IN NEW YORK STATE [1]

B. H. Paul

In a study of reforesting methods used in New York State and the results that may be obtained by planting forest trees on denuded lands and on worn-out agricultural lands, thirty-five typical forest plantations in various parts of the State (Fig. 108) were visited in the summer and fall of

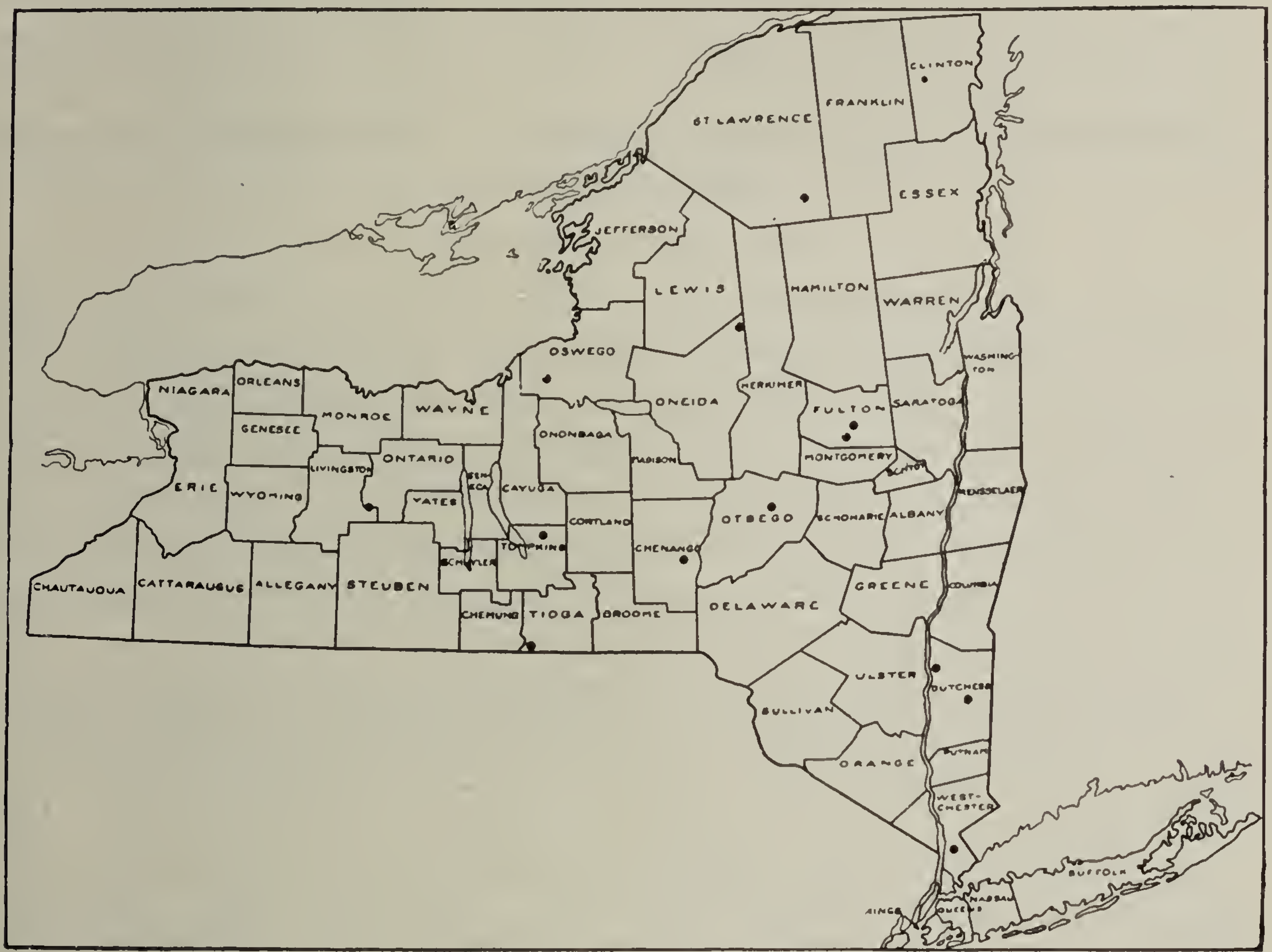

FIG. 108.— LOCALITIES IN WHICH PLANTATIONS WERE VISITED

The localities are indicated by dots

1914, and detailed studies were made of conditions of growth and rate of growth of the trees.

The majority of the plantations in the State are comparatively young. Very little reforesting was done prior to the year 1899, when the New York State College of Forestry at Cornell University made its first forest plantation at Axton, in the Adirondacks (see frontispiece). Since 1899 planting has been done on state lands nearly every year, and up to the present time a total of over 7000 acres has been reforested within the Adirondack and Catskill forest preserves.

[1] In a subsequent bulletin the possibility of forest management in New York State will be considered, together with probable yields in timber and money.

In 1908 the State began supplying trees to individual persons at cost of production, and from these sales about 15,000 acres of privately owned lands have been reforested. In addition, 3000 acres of state land have been reforested at various state institutions, and between 5000 and 6000 acres have been privately reforested with trees purchased from commercial dealers or grown in private nurseries.

Plantations established prior to 1899 with imported nursery stock or by sowing tree seeds are to be found at Millbrook and at White Lake Corners. The age of these plantations ranges from eighteen to forty-four years; the present yields are given on pages 679 and 687 of this bulletin.

CONDITIONS FOR ESTABLISHING A SUCCESSFUL FOREST PLANTATION

PLANTING SEASONS

There are two seasons of the year when plantations of forest trees may be made. In New York State the first season begins in the latter part of March on Long Island, and continues often as late as May 25 in the Adirondacks. Spring planting should be done before the buds have begun to make new growth. When trees are moved from a warm locality to a colder one for planting, the new bud growth often gets well started before the ground in which the trees are to be planted is ready to receive them. The reverse is true when the trees are moved to a warmer place for planting, since here the soil is ready long before the frost is out of the ground in which the trees have grown. For these reasons it is decidedly advantageous to have planting stock grown in the vicinity where the planting is to be done.

As a general rule, spring planting should be done as soon as the soil is sufficiently dry to be worked. On Long Island and in the southeastern part of New York State, this is about the last week of March and the first week of April. In the Adirondacks and the northern parts of the State, it is usually not possible to begin planting before the last week of April.

The fall planting season begins about the first of September in northern New York and ends about the last of October in southern New York and Long Island. In planting conifers in the fall, only transplanted stock three or four years old should be used; with seedling stock much loss may result from heaving of the soil. Hardwood species to be planted in the fall should not be moved until after the leaves have fallen.

In spring early planting is to be preferred in order that the trees may have the benefit of the spring rains. If planting is done too early in the fall, however, the trees may suffer from subsequent dry weather. But fall planting should be done early enough so that the soil will become well compacted about the roots by the autumn rains before the ground freezes;

late fall planting is likely to result in heaving of the trees during the winter and early spring.

Trees that show a tendency to start their new growth very early in the spring — for example, the European larch — should preferably be planted in the fall.

Dividing the planting between the spring and fall seasons is often advantageous when sufficient labor cannot be obtained to do the required work in the short space of time afforded in only one planting season.

KINDS OF TREES TO BE USED

There are a large number of species of trees that may be used for forest planting. For commercial purposes, however, and for supplying materials needed for domestic use on the farm, only a few species are of real value. For New York State the most rapidly growing species and those giving the most valuable product are:

Conifers	Hardwoods
White pine (*Pinus strobus*)	White ash (*Fraxinus americana*)
Norway spruce (*Picea excelsa*)	Red oak (*Quercus rubra*)
Red pine (*Pinus resinosa*)	Black locust (*Robinia pseudacacia*)
Scotch pine (*Pinus sylvestris*)	Black walnut (*Juglans nigra*)
European larch (*Larix europæa*)	Tulip tree (*Liriodendron tulipifera*)
White cedar (*Thuya occidentalis*)	Basswood (*Tilia americana*)
	Carolina poplar (*Populus deltoides* var.)

SOIL TYPES TO WHICH DIFFERENT TREE SPECIES ARE ADAPTED

In general the different species of pine require sandy soils or sandy loam. European larch does well on upland loam soil, while white cedar thrives best in low, moist situations. Norway spruce does best on a heavy loam or clay soil. Hardwoods are best adapted to the better loam soils and clay soils. The trees best suited for growth in various soils are as follows:

Dry sandy soil	Moist sand or sandy loam	Moist loam or clay loam
Scotch pine	White pine	Norway spruce
Red pine	European larch	White cedar
Black locust	White cedar	White ash
Carolina poplar	Black locust	Red oak
	Carolina poplar	Black walnut
		Tulip tree
		Basswood
		Black locust
		Carolina poplar

Areas that are covered with water at certain periods during the year should not be planted with trees, since tree roots need air as well as moisture in the soil. A well-drained soil containing a moderate amount of moisture gives the best conditions for tree growth.

WHERE TO OBTAIN TREES FOR PLANTING

Trees for reforesting may be raised from seed, purchased from commercial nurserymen, or obtained from state departments in States maintaining a forestry division. In New York State, trees to be used for reforesting within the State are sold by the Conservation Commission at

FIG. 109. NEW YORK STATE FOREST TREE NURSERY AT SARATOGA

cost of production. A special resolution of this Commission, passed in March, 1915, permits the sale of trees to municipalities, public schools, and institutions supported by public charity, at a nominal rate of fifty cents per thousand trees.

The hardwood species mentioned, except basswood and tulip poplar, may be easily raised by planting the seeds in beds or nursery rows. The raising of conifers from seed requires considerable skill and experience for successful production.

AGE OF PLANTING STOCK

The success obtained with planting stock of different ages depends more on the character of the site, the supply of soil moisture during the first

summer, and the amount and character of the natural plant growth already present, than on the age of the trees themselves. In favorable situations and during favorable growing seasons, as great success has been attained with two-years-old seedlings as with older stock. However, where conditions are in any way unfavorable, the better results obtained from the use of transplants three or four years old more than make up for the greater initial expenditure for the trees themselves and for planting. Seedlings should be used only when the soil is such that a prolonged dry period following the planting would not cause a heavy loss.

In some cases the number of trees handled, the distance they have to be moved, or the accessibility of the land to be planted, may prove to be the most important factor of cost in the establishment of a plantation. A good rule to follow in such cases is to use just as small a tree as will be sure to grow under the conditions existing where it is to be planted. From an economical standpoint, this rule may be applied generally, since one or two years in the age of the trees planted is of relatively little importance when compared with the time required for maturity of the plantation. Larger planting stock is usually preferred, however, since most persons are desirous of seeing rapid development of their plantations. For extensive planting on sites of varying character, three- and four-years-old transplanted stock should always be used.

CARE OF STOCK DURING TRANSPORTATION

Too much emphasis cannot be placed on the proper handling of trees from the time when they are removed from the nursery rows until they are finally planted. Many losses occur because of lack of knowledge or neglect at some time during transportation or planting of the trees. Two important rules to be observed in the handling of trees are, first, never to let the roots get dry, and second, never to leave the roots exposed to direct sunshine. For the best success, these rules are fundamental.

As soon as the trees are removed from the nursery rows, they should be tied in bundles and packed for shipment; if shipment cannot be made immediately, they may be heeled in for a few days. The trees should be packed firmly in willow baskets or wooden crates, with a plentiful supply of damp moss packed about the roots to keep them moist. The tops of the trees should be allowed as much air as possible, but the bundles should be so closely packed that they cannot move about during transportation. Well-made wooden crates have proved very satisfactory for use in shipping trees, since they are easier to handle than willow baskets and can be loaded more compactly when the trees are to be hauled by team or on automobile trucks.

Trees should never be left standing packed in baskets or crates any longer than is absolutely necessary. As soon as they are received at the station, they should be taken at once to the planting site and unpacked.

HEELING IN

For heeling in the trees when unpacked, a situation should be chosen that is centrally located with reference to the area to be planted; or, if a large plantation is to be made, the trees may be distributed at several points. The trees should be heeled in where they can be protected from sunshine and where water can be readily obtained.

The usual method of heeling in is as follows: Trenches are dug, along which the trees are to be placed at an angle of about 45 degrees. The roots of the trees are first dipped in water, then the bundles are cut and the trees are spread out so that they form a layer not more than two inches in thickness along the side of the trench. The roots are then covered with dirt, which is firmly packed down with the feet. Trees heeled in in this way should be watered frequently, since transpiration of water from the needles is constantly going on.

Covering the trees with evergreen boughs while they remain in the trenches is an excellent practice if they are exposed to sunshine. If the trees are to be held for only a short time, a marshy place where the roots may be kept in cool running water will afford a very easy and satisfactory situation for heeling in.

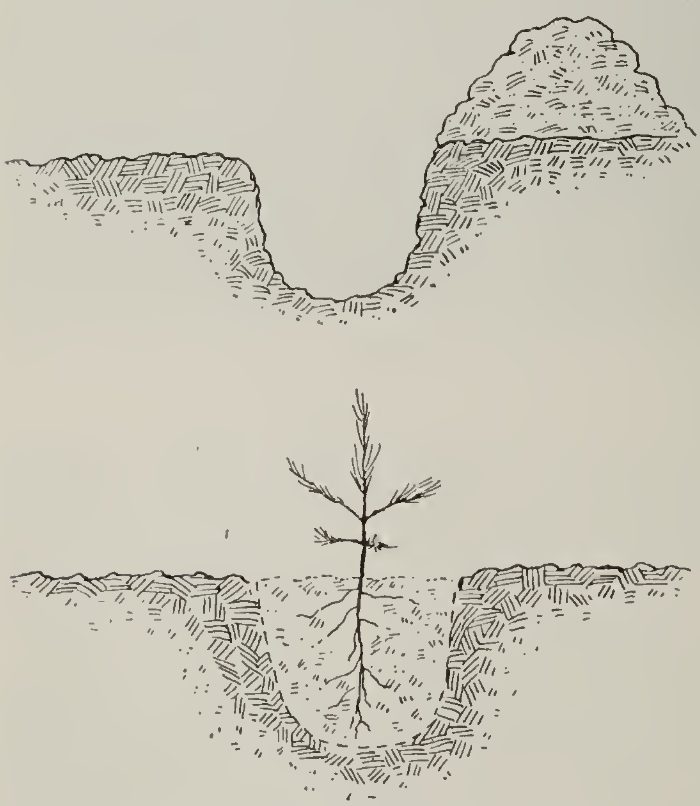

FIG. 110. THE HOLE METHOD

Trees should be heeled in each day at points easily accessible to the planters. The planters should carry the trees in pails containing sufficient water to keep the roots covered. Some planters prefer to carry the trees wrapped in damp moss or burlap, but this method is likely to promote carelessness.

PLANTING METHODS

The principal methods actually in use in forest planting are the hole method, the furrow-hole method, and the mattock-slit method.

In the hole method two men work together. One removes with a mattock the sod or other vegetation growing on the soil, from an area from fourteen to sixteen inches square, and digs a hole of sufficient depth,

leaving the loose earth in a small mound close to the edge of the hole. The second man sets the tree in the hole, spreads out the roots, pushes in the loose soil, firms it around the roots with his hands until the hole is nearly filled, then makes it firmer by tramping it down with his feet, and finally fills the hole completely, leaving a layer of loose soil on the top. This method, although somewhat slower than the others, is by far the most satisfactory, especially on unfavorable sites.

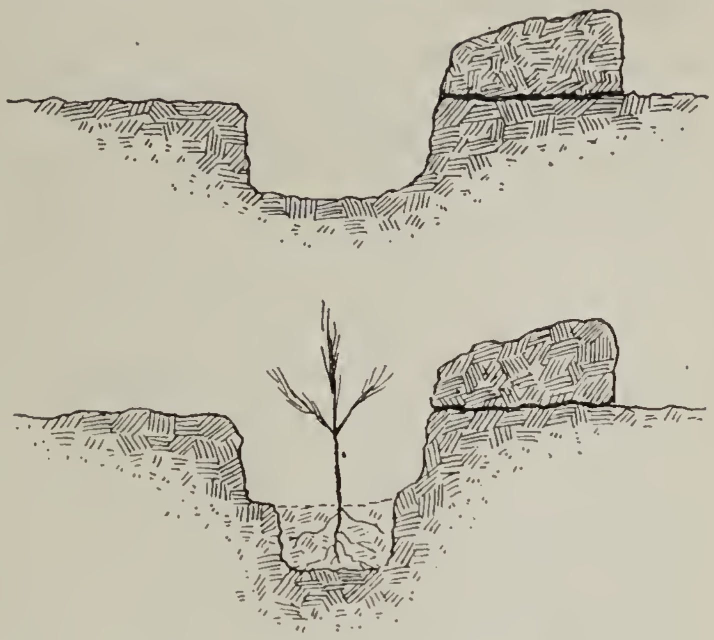

Fig. 111. The furrow-hole method

The furrow-hole method consists in plowing furrows six feet apart throughout the area to be planted, and setting the trees in the bottom of the furrows, usually by the hole method. This method has an advantage over the hole method in getting all sod and other vegetation out of the way of the planter, thus facilitating the planting. The furrow-hole method also furnishes a more liberal supply of loose earth for use in planting the tree, and allows deeper placing in the soil, thus assuring better moisture conditions on dry sites and in sandy soils. It can be used, however, only where the character of the ground is such that plowing may be done.

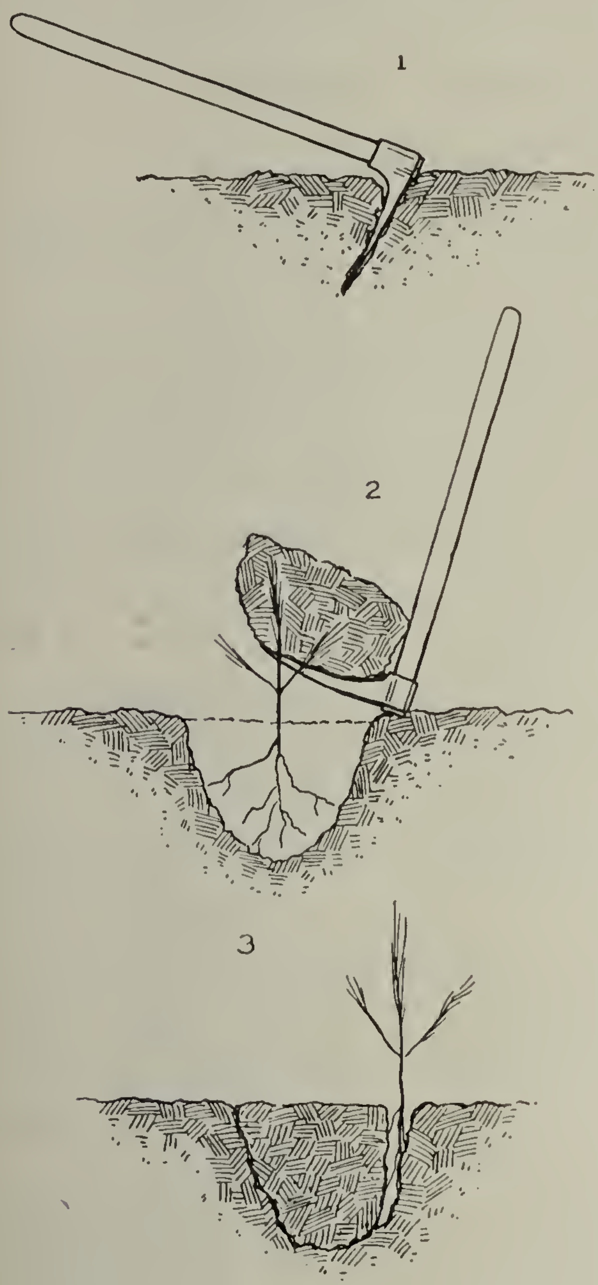

Fig. 112. The mattock-slit method

The mattock-slit method has developed from the hole method, and is much quicker though not quite so satisfactory. In using the mattock-slit method the sod may be either removed or left, although it is considered better practice to remove it. The mattock is driven into the soil for the full length of the blade, and then the handle is pushed backward and to one side, thus opening the ground at one side of the mattock sufficiently to slip the lower part of the tree under it. The mattock is then removed and the soil is allowed to fall back to its former position.

The soil is firmed about the tree by tramping with the feet. This method has been fairly satisfactory on a clay loam soil.

The care exercised by the men planting the trees often has as much to do with the amount of loss as does the planting method used. When proper care is taken in planting, the relative merits of the different planting methods may be summed up as follows:

For all situations the hole method is the most reliable, since it gives the tree roots and the tree itself more nearly natural conditions than do either of the other methods. The furrow-hole method differs from the hole method in placing the tree in the bottom of the furrow, thus frequently bringing the roots of the tree into a layer of soil low in fertility; however, any loss due to low fertility would probably be compensated by the better moisture conditions obtained by setting the tree lower in the soil. The mattock-slit method results in a crowding of the roots against one side of the hole; yet on favorable sites, where the sod was removed, it has been very successful. The removal of the sod allows the tree to stand in a moisture-collecting depression, and leaves a clear space around it free from competing vegetation.

The results obtained by different planting methods on different types of soil are shown in table 1:

TABLE 1. RELATION OF PLANTING METHOD TO LOSS IN WHITE PINE PLANTATIONS

Locality	Year planted	Age of stock* (years)	Soil type	Planting method	Number of trees counted	Per cent living
Ithaca......	1913	2–2	Dunkirk clay loam	Hole method	90	87
Ithaca......	1913	2–2	Dunkirk clay loam	Mattock-slit method; sod removed	90	86
Ithaca......	1913	2–2	Dunkirk clay loam	Mattock-slit method; sod not removed	56	62
Ithaca......	1912	2–2	Dunkirk clay loam	Furrow-hole method	200	90
Johnstown...	1912	2–1	Dunkirk sandy loam	Hole method	500	70
Johnstown...	1912	2–1	Dunkirk sandy loam	Furrow-hole method	200	†98
Norwich....	1912	2–2	Volusia silt loam	Hole method	300	78
Norwich....	1912	2–2	Volusia silt loam	Furrow-hole method	200	94

* The first figure indicates the number of years the stock remained in the seed bed; the second indicates the number of years in the transplant rows.

† The soil in this section was not quite so sandy as in that part of the area where the hole method was used.

SPACING

In forest planting the spacing of the trees may range from 4 by 4 to 8 by 8 feet. The most general spacing used is 6 by 6 feet, requiring twelve hundred and ten trees to an acre. With this spacing, such species as white pine and norway spruce shed their lower branches more quickly and this produces a better grade of timber. Other species, such, for example, as black locust and carolina poplar, shed their branches sufficiently when spaced 7 by 7 or 8 by 8 feet.

Close spacing of trees tends to increase height growth at first; but unless suitable thinnings are made, when the plantations reach an age of from fifteen to twenty years competition becomes so great that growth is checked and many of the trees are crowded out and die. Too wide spacing, on the other hand, is also to be avoided, since this allows development of too many branches. Close spacing, followed by judicious thinnings at the right time, produces the best quality of timber in the shortest possible period.

The initial cost per acre of establishing the plantation is greatly increased by close spacing.

RATE OF PLANTING AND AVERAGE COST PER ACRE

Two men working together by the hole method can plant, on an average, from one thousand to twelve hundred trees in a day. On sandy soils with little sod or grass, as many as fourteen hundred have been planted by two men in a day. On very stony soils or where there is a heavy sod, the rate of planting is relatively lower. The average cost of planting should not exceed six dollars an acre under favorable conditions. The total cost of establishing a plantation, including cost of trees, freight, and labor, varies from seven to twelve dollars an acre.

COMPETING VEGETATION

A moderate amount of competing vegetation does not interfere to any great extent with the development of a plantation. In fact, a small growth of grass and weeds has produced favorable results in newly made plantations by protecting the young trees from hot sunshine during the first summer.

Where the competition with other vegetation is very strong, however, the young trees may not be able to withstand it unaided. Newly cleared hardwood land that will give rise to a vigorous growth of sprouts is not well adapted for the planting of pine unless several subsequent cleanings are made to provide room for the planted trees. This should be done when it is desirable to change inferior hardwood sprout land to a coniferous forest. A very heavy growth of herbaceous vegetation may check the development of a plantation for a time, but unless the trees are com-

pletely shaded out by it while very small they will finally attain sufficient height so that they are no longer hampered by it. The point to be emphasized here is the effect of a heavy growth of tall grass and weeds, such as is found in the 1909 plantations at Hemlock Lake, or the occupation of the area by hardwood sprouts and briers, as is the case in the Waverly plantation (page 663). In both these places the development of the trees has been very slow, and this is attributed to the large amount of competing vegetation that occupies the soil.

TABLE 2. Relation of Competing Vegetation to Average Annual and Total Height Growth

(White pine, 2–1 transplants planted in 1909)

Locality	Average height growth (in feet)				Competing vegetation	Average total height (feet)
	1914	1913	1912	1911		
Hemlock Lake	0.95	1.08	0.705	0.507	Heavy growth of grass and weeds	3.89
Waverly	0.61	0.60	0.68	0.49	Sprouts and young saplings	3.04
Cooperstown	1.63	1.20	1.47	0.88	Medium growth of grass	6.27
	1.43	1.21	1.30	0.53		5.89
	1.68	1.30	1.50	0.77		6.33
Fulton	2.02	1.97	1.58	1.15	No vegetation	7.71

The effect of competing vegetation on the average annual and total height growth for plantations of white pine made in 1909 is shown in table 2. The table indicates that a heavy growth of competing vegetation keeps down the development of the plantation. The reason for this is the fact that these competing plants use the moisture needed by the trees, make a rapid growth, spread out over the young trees, occupy the whole area, and shut off the sunlight that the young trees need for their development. The type of soil determines the amount of competing vegetation; heavy soils support a much more luxuriant growth of grass and weeds than do soils of a dry and sandy nature.

SHADE

The effect of shade on plantations has already been mentioned. A comparison of young plantations made where partial shade was afforded by grass and weeds during the first two years, with plantations made under similar conditions where there was no shade, shows results highly in favor of shade for the young plantations, especially during periods of dry weather. For example, in plantations of white pine and scotch pine on a clay loam soil near Ithaca, the grass between the rows of trees was removed in July.

Counts made in December of the same year showed a loss of forty per cent for the white pine, in addition to twelve per cent of the trees that had been cut off by the mowers, and sixteen per cent that were in poor condition; only thirty-two per cent of the trees counted [2] were doing well. In the scotch pine plantation results were similar: fifty-five per cent of the trees were dead, fifteen per cent had been cut off by the mowers, five per cent were in poor condition, and only twenty-five per cent were doing well. The high percentage of loss was caused by the sudden exposure of the young trees to hot sunshine when the protection that had been given them by the grass was taken away.

A similar effect of shade on young plantations is noted in white pine plantations in the Harvard forest, Petersham, Massachusetts, made in 1912.[3] Where the trees received no shade in this plantation there was a loss of forty-three and one-half per cent; where the trees received high shade for from one to three hours a day the loss was reduced to nineteen per cent; and where the high shade lasted over four and one-half hours a day the loss was only seven per cent. Where medium low shade alone was provided the loss was nineteen per cent, and with heavy low shade the loss was reduced to thirteen per cent. With a combination of both high and low shade the loss ranged from nothing to eighteen per cent, being greatest where very heavy low shade was present under high shade. This suggests a point of optimum shade that has been passed where a combination of high shade and heavy low shade exists.

While a certain amount of shade is of value to young plantations, its continuation as the trees become older produces very unfavorable results, especially with the more intolerant species. This statement is made with particular reference to underplanting. Trees planted under the shade of older trees do not make such rapid development, and are not so strong and sturdy, as trees planted in the open. This point is illustrated very clearly in a comparison of figures 113 and 114 (page 660), showing, respectively, red pine planted in the open and red pine planted under a rather open stand of hardwoods. Similar results have also been observed in scotch pine plantations in the open and underneath hardwoods. Norway spruce planted in the open and in underplanting does not show so marked a contrast in its development as do the pines, since it can bear more shade than can the other species.

The present indications in underplanting seem to be that unless the overhead shade is removed within a few years after the planting is done, especially in the case of trees that cannot endure shade, the trees will be less vigorous and will fall off rapidly in their rate of growth.

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[2] The number of trees counted was 126 white pine and 182 scotch pine.

[3] Kimball, G. W., and Carter, E. E. Influence of shade and other factors on plantations. Forestry quarterly **11**: 176-184. 1913.

FIG. 113. RED PINE PLANTED BY GLOVERSVILLE WATER WORKS IN 1910

FIG. 114. RED PINE PLANTED UNDER HARDWOODS ON SHALLOW, ROCKY SOIL AT HYDE PARK, 1910, FOUR YEARS AFTER PLANTING

RESULTS OF FOREST PLANTING

DESCRIPTIONS AND DEVELOPMENT OF YOUNG FOREST PLANTATIONS

During the summer and autumn of 1914 thirty-five typical forest plantations in various parts of this State (Fig. 108) were visited, and detailed studies of conditions of growth and rate of growth were made. The results of these studies appear in tabulated form on pages 670 and 671. The locations and general descriptions of the plantations visited are as follows:

HEMLOCK LAKE

The first plantations in the vicinity of Hemlock Lake were made in 1901. They comprised several acres of white pine and norway spruce planted

FIG. 115. WHITE PINE AND NORWAY SPRUCE PLANTED IN 1901 ON LANDS OF THE ROCHESTER WATER COMPANY

Age of trees when photographed, thirteen years

in alternate rows, near the top of a ridge, on the east side at the upper end of Hemlock Lake, and a smaller area of the same species on the west side at the lower end of the lake. The trees in these plantations, especially in that at the upper end of the lake, were badly damaged while small by the inroads of livestock, and as a result the stand is somewhat open and irregular. Further damage to both the white pine and the norway spruce (but more frequently to the white pine) has been caused by attacks of the white pine weevil (*Pissodes strobi* Peck).

Both species are making excellent growth. The pine seemed to be dominant at first, but it is now being overtaken by the spruce because

of the more rapid growth of the latter. The trees at the lower end of the lake have attained greater height and greater diameter than those at the upper end, due probably to better soil and better moisture conditions.

In 1909 a second planting was made on the east side near the lower end of the lake, with three-years-old white pine stock imported from Germany. The soil is a silt loam approaching clay, and supports a very heavy growth of weeds and grass with which the young trees have to compete. A number of trees were removed from this plantation because they were found to be affected by the blister rust of the white pine (*Peridermium strobi* Klebahn).

COOPERSTOWN

Cooperstown is in Otsego County, on the south side of the divide that separates the Mohawk and Susquehanna watersheds, at an elevation of

FIG. 116. PLANTATION OF WHITE PINE, FIVE YEARS OLD, ON THE CLARK ESTATE, COOPERSTOWN

1250 feet above sea level. The plantations studied are situated on the Clark estate, about one mile southeast of the village of Cooperstown. In 1909 sixty acres were planted with three-years-old white pine stock imported from Germany. The plantations are located on the east and the west slopes of a low ridge, in shallow, stony soil. Prior to the planting of the trees, this land had been used for pasture. The only competing vegetation consists of grass, goldenrod, and briers. The trees are making rapid development. At the age of five years they averaged six feet in

total height, and they have spread out to such an extent that there is scarcely room to walk between the rows.

A large number of the trees in this plantation have been attacked by the white pine weevil in spite of the efforts that are being put forth to ward off this insect. Many of the beetles are caught in nets at the time when they are flying about on the trees in May, and later all leaders on the trees that show attacks of the insect are cut out and burned. In some places as many as twenty per cent of the trees show the effects of weevil attacks in the past three or four years.

NORWICH

Norwich is in Chenango County, about twenty-five miles southwest of Cooperstown. The plantations in this vicinity were made by the Norwich Cemetery Association and the Norwich Water Company.

The plantations of the Norwich Cemetery Association are one mile south of the city, on a very steep eastern slope adjoining the cemetery. The soil here is very thin and stony. The oldest plantations, made in 1910 near the bottom of the slope, are of scotch pine and norway spruce. Just above these and extending well up the slope is a large area planted to white pine in 1912. The furrow method of planting was used in each case. The only competing vegetation consists of a rather light growth of grass. The proportion of loss in these plantations is comparatively low.

The plantations of the Norwich Water Company are about two miles north of the city, on the slopes adjacent to the city water supply reservoir. The main plantation consists of white pine and norway spruce, planted separately on a low ridge between two small streams tributary to the reservoir. These plantations were made in 1912 with four-years-old transplants. Since the trees were planted, the ground has received rough cultivation between the rows to keep out grass and weeds. The soil is very stony in places, and it is here that the greatest losses occur, the total loss of white pine being twenty-two per cent and of norway spruce sixteen per cent. In this plantation the white pine is making more rapid development than the spruce in height growth.

WAVERLY

Waverly is in the Susquehanna River Valley, in Tioga County, near the Pennsylvania state line. The elevation above sea level is 824 feet, and the adjoining hills are from 500 to 600 feet higher. The only plantation visited in this locality is on the farm of A. G. DuBois, four miles southeast of Waverly village. It consists of about eight acres planted in 1909 with white pine, three years old, imported from Germany, and is situated at an elevation of about 200 feet above the river valley. The original forest growth was removed from the area ten years before the time of planting, and during this interval grass crops were being produced.

The development of the trees in this plantation is very slow, probably due to the fact that the ground is fast becoming occupied by a number of hardwood species which are crowding out the pines and hindering their development. In 1910 the failed spaces were planted with four-years-old transplants, yet the percentage of trees now living is only eighty.

FULTON

Fulton is in Oswego County, about twenty-five miles north of Syracuse. The plantations of the Great Bear Spring Water Company, four miles south of the village of Fulton, are among the earliest of the more extensive forest plantations in this State. These plantations are located on

FIG. 117. SCOTCH PINE PLANTATION, FOUR YEARS OLD, ON LANDS OF THE GREAT BEAR SPRING WATER COMPANY NEAR FULTON

both sides of the right of way of the electric railroad between Syracuse and Oswego, and can be readily seen from the car lines. In 1907 about twenty acres of rather sandy, knolly land, bordering the Oswego River, were planted with scotch pine stock imported from Germany by a New Jersey nursery. In 1909 several acres more of scotch pine, fifteen acres of scotch pine and white pine planted in alternate rows, and about five acres of white pine, were added to the first plantation near the river, and an area of sixty acres in the eastern part of the water company's holdings was planted with three-years-old transplants of white pine imported from Germany. In 1910 between fifty and sixty acres of scotch pine were added to the last plantation. The Great Bear Spring Water Company is still

planting trees on its lands and at present has about 350,000 trees set. Among the species more recently planted are tamarack (*Larix laricina* [DuRoi] Koch), white cedar, red pine, and western yellow pine (*Pinus ponderosa* Dougl.).

Both the scotch pine and the white pine planted on the sandy knolls along the river are making very rapid growth. The white pine planted here is growing faster than the same species planted at the same time on the eastern part of the tract. There are several large springs in the hollows between the sandy knolls, indicating plenty of underground moisture, and this undoubtedly aids greatly in the development of the trees planted in this situation. The soil in the eastern part of the tract is much heavier and shows a tendency to be marshy in places during rainy seasons. In other places the soil is very stony. The 1909 plantation of white pine in this situation has been very successful. The trees have made a very uniform growth and the proportion of loss is very low. The same is true of the adjacent scotch pine plantation made in 1910.

GLOVERSVILLE AND JOHNSTOWN

Gloversville and Johnstown are in the southern part of Fulton County. The elevations in this vicinity range from 800 to 1300 feet. The plantations in this locality were made by the Gloversville Water Company, Jeremiah Wood, David A. Hays, and the Johnstown Water Company.

The plantations of the Gloversville Water Company are located three miles north of the city, on the slopes of the drainage basin of the water supply reservoir. The oldest plantations here were made in 1908, on a sandy slope bordering the south side of the reservoir, with four-years-old transplants obtained from the New York State nursery at Lake Clear Junction. These plantations comprise five acres of white pine and four acres of scotch pine. Both species have developed very satisfactorily. The white pine has attained an average height of nearly nine feet; ninety-eight per cent of the trees are living, and the branches have developed sufficiently to meet between the rows, thus shading the ground completely. The development of the scotch pine is about equal to that of the white pine. All the competing vegetation is being eliminated from these plantations by the heavy shade, and a good forest cover is being rapidly established. In 1909 another plantation of white pine was made on the opposite side of the reservoir, with three-years-old transplants of German stock. The trees there are not doing as well as those planted in 1908, yet they are better than in some plantations made in the same year in other localities with similar stock. In 1910 twenty thousand three-years-old transplants of red pine were planted on a sandy ridge just west of the reservoir, and another large area was planted with scotch pine stock

of the same age. Both the red pine and the scotch pine are developing very satisfactorily.

The plantations of Jeremiah Wood are situated eight miles west of the city of Gloversville, on the slopes and the tops of sandy gravelly knolls the soil of which is very unproductive. A departure from the general practice in forest planting is found here. The rows of trees are spaced twelve feet apart, and the trees six feet apart in the rows. By this method Mr. Wood has cut down the initial cost of establishing plantations. Artificial pruning of the side branches has been practiced, since by this

FIG. 118. WHITE PINE PLANTATION, SIX YEARS OLD, ON THE WATERSHED OF THE GLOVERSVILLE WATER COMPANY

method of planting natural pruning would not take place for a very long time. With artificial pruning, the aim is to have all the wood produced in the first sixteen-foot log free from knots, with the exception of a core not more than two inches in diameter in the center of the log. This practice seems feasible, provided not enough of the crown is removed to interfere with the growth of the tree. However, this does not obviate the tendency of the tree to develop laterally as well as vertically as long as light is available from the sides. The greatest difficulty here seems to be that too much of the ground is left exposed to sunlight, thus allowing the growth of grass and weeds which utilize much of the moisture in the soil. The gravelly nature of the subsoil in this locality

makes it necessary to establish a forest cover as quickly as possible in order to secure and maintain organic matter in the surface layers of the soil which will aid in the retention of soil moisture and add fertility to the soil. Mr. Wood made his first plantation in 1908, followed by others in 1909. A large proportion of the trees are living, but the growth has been relatively slow, due mainly to the conditions already mentioned.

The plantations of David A. Hays are on a nearly level sandy area of about one hundred acres, five miles northwest of the city of Johnstown. Much of the area is practically barren, and in places the sand has been blown out and drifted by the wind. The scotch pine, planted in 1909 and 1910, has been very successful. In the white pine, planted later, there is a loss as high as thirty per cent. The most successful results with white pine on this area were obtained by plowing furrows and planting the trees in the bottom of the furrows. With this method the loss was only two per cent.

The two plantations of the Johnstown Water Company are near those of Mr. Hays and on soil of a similar nature, although the character of the topography is more rolling. The scotch pine has been the more successful, with a loss of only nine per cent for a plantation made in 1910. The white pine, planted in 1911 on a rolling sandy knoll with a southern exposure, shows a loss of thirty-five per cent.

MILLBROOK

Millbrook is in the western part of Dutchess County, about fifteen miles from the Hudson River. The elevation ranges from 500 to 900 feet. The forest plantations in the vicinity of Millbrook consist of about fifteen acres of white pine belonging to Oakleigh Thorne, planted in 1909; fifteen acres of white pine, red pine, white oak (*Quercus alba* L.), and red oak, planted by Samuel Thorne in 1903 in cooperation with the United States Forest Service; and several plantations of norway spruce, white pine, scotch pine, and European larch, made by Charles F. Dietrich. The Dietrich plantations are described in detail on pages 674 to 679.

The plantation of Oakleigh Thorne is situated one mile northwest of Millbrook, on rolling gravelly knolls. Eighty per cent of the trees planted are living; about one-half of these, or forty per cent of the original number planted, have been damaged by attacks of the white pine weevil. Many of the trees attacked will recover by sending up side branches to replace the terminal shoots, but, at the very best, so large a percentage of damage will result in an uneven development of the stand.

The plantations of Samuel Thorne are situated on the top of a stony, rocky ridge about one mile south of Mr. Thorne's residence. The soil is

very shallow and stony. The white pine was originally planted with black locust, but before the locust attained a growth suitable for use it was killed by attacks of the locust borer (*Cyllene robiniae* Forst.) and was subsequently removed. As a result the white pine stand was left in a rather open condition, allowing the development of many side branches which now give an irregular appearance to the stand. The openings left by the removal of the locust have recently been planted with seedlings of white ash.

The red pine planted the same year shows a very satisfactory development for this character of site. The trees are from fifteen to eighteen feet in height, and are straight and well developed.

FIG. 119. WHITE PINE PLANTATION, FIVE YEARS OLD, ON A STEEP, ROCKY SLOPE AT HYDE PARK

The red and the white oak planted the same year have reached a height of about fifteen feet and a diameter of from one to two inches. The soil here is too poor for a very satisfactory growth of hardwoods.

HYDE PARK

The plantations at Hyde Park are located on the estate of Archibald Rogers, and constitute a part of the work being carried on by Mr. Rogers in accordance with a plan of forest management for his timberland prepared in cooperation with the United States Forest Service. Mr. Rogers made his first forest plantation in 1909, when two small areas, one on a steep, rocky ridge near the Hudson River, and the other on a more

level area near the eastern boundary of his estate, were planted with white pine. More recent planting has been done, both in open fields and underneath a rather open stand of hardwoods. The soil type is a stony and very shallow loam. The underlying layers of rock are inclined at such an angle as to cause frequent outcrops of sharp ridges and ledges of rock. The results of these plantations are very satisfactory, although the trees have suffered slightly from weevil attacks. The plantations have a rather open appearance, caused by the presence of a considerable amount of exposed rock at the surface of the soil.

ITHACA

Ithaca is in Tompkins County, at the southern end of Cayuga Lake. The only plantations in the vicinity are those made by the Department of Forestry of the New York State College of Agriculture at Cornell University, beginning in the spring of 1912. The first year a number of experimental plots were planted with white, red, and scotch pine, on a gravelly loam soil along Fall Creek, about one mile from the College, and a plantation of twenty thousand four-years-old transplants of white pine was made on clay loam soil near Varna four miles farther up the same stream. Planting at Varna has been continued in 1913, 1914, and 1915 with white pine, scotch pine, and red pine, amounting at present to about one hundred and fifteen acres.

Because of the fact that these plantations are very young, the only information of value that can be derived from them consists of mortality counts for different species of trees planted on different types of soil by different planting methods.

SUMMARY

The data for the plantations discussed are summarized in table 3:

TABLE 3. SUMMARY OF

Plantation	Location	Planted by	Species	Area (acres)	Year planted	Season planted	Spacing (feet)
1	Hemlock Lake	Rochester Water Company	White pine and norway spruce	6	1901	April and May	6 x 6
2			White pine and norway spruce	3	1901	April and May	6 x 6
3			White pine	10	1909	Spring	6 x 6
4	Cooperstown	Clark estate	White pine	10	1909	Spring	6 x 6
5			White pine	20	1909	Spring	6 x 6
6			White pine	30	1909	Spring	6 x 6
7	Norwich	Norwich Cemetery Association	Scotch pine	5	1910	Spring	6 x 6
8			Norway spruce	3	1910	Spring	6 x 6
9			White pine	30	1912	Spring	6 x 6
10		Norwich Water Company	White pine	15	1912	Spring	6 x 6
11			Norway spruce	5	1912	Spring	6 x 6
12	Waverly	A. G. DuBois	White pine	8	1909	Spring	6 x 6
13	Fulton	Great Bear Spring Water Company	Scotch pine	20	1907	Spring	4 x 6
14			Scotch pine	10	1909	Spring	6 x 6
15			White pine	15	1909	Spring	6 x 6
16			White pine	60	1909	Spring	6 x 6
17			Scotch pine	50	1910	Spring	6 x 6
18	Gloversville	Gloversville Water Company	White pine	5	1908	Spring	6 x 6
19			Scotch pine	4	1908	Spring	6 x 6
20			White pine	5	1909	Spring	6 x 6
21			Scotch pine	20	1910	Spring	6 x 6
22			Red pine	20	1910	Spring	6 x 6
23		J. Wood	White pine	5	1908	Spring	6 x 12
24			White pine	5	1909	Spring	6 x 12
25			White pine	5	1909	Spring	6 x 12
26	Johnstown	David A. Hays	Scotch pine	5	1909	Spring	8 x 8
27			Scotch pine	10	1910	Spring	8 x 8
28			White pine	20	1912	Spring	8 x 8
29			White pine	10	1912	Spring	8 x 8
30			White pine	10	1913	Spring	8 x 8
31		Johnstown Water Company	Scotch pine	5	1910	Spring	8 x 8
32			White pine	30	1911	Spring	8 x 8
33	Millbrook	Oakleigh Thorne	White pine	15	1909	Spring	6 x 6
34	Hyde Park	A. Rogers	White pine	5	1909	Spring	6 x 6
35			White pine	5	1909	Spring	Irregular

* In this column the first figure refers to the number of years that the trees remained in the nursery

Data for Plantations

Age of stock*	Planting method	Soil type	Competing vegetation	Damage		Number of trees counted	Percentage living
				Cause	Amount (per cent)		
....	Hole.....	Volusia shale loam...	Grass and weeds.	Grazing by stock, and weevil	20–30	100	60
....	Hole.....	Genesee shale loam ..	Grass and weeds.	Grazing by stock, and weevil	25	100	65
2–1	Hole.....	Dunkirk silt loam....	Heavy growth of grass and weeds	Blister rust.....	1–2	300	72
2–1	Hole.....	Volusia silt loam	Light growth of grass	Weevil.........	13	500	80.6
2–1	Hole.....	Volusia silt loam	Light growth of grass	Weevil.........	15	1,000	83
2–1	Hole.....	Volusia silt loam	Light growth of grass	Weevil.........	20	1,000	78
2–1	Furrow...	Volusia silt loam	Light growth of grass	....	....	200	95
2–1	Furrow...	Volusia silt loam	Light growth of grass	....	....	200	87
2–2	Furrow...	Volusia silt loam....	Light growth of grass	....	....	200	94
2–2	Hole.....	Volusia silt loam	None..........	....	....	300	78
2–2	Hole.....	Volusia silt loam	None..........	....	....	200	84
2–1	Hole.....	Volusia silt loam	Hardwood sprouts, briers, and grass	Weevil.........	5	200	80
2–1	Hole.....	Dunkirk silt loam ...	Very little grass.	....	....	200	95
2–1	Hole.....	Dunkirk silt loam ...	Very little grass.	....	....	100	95
2–1	Hole.....	Dunkirk silt loam ...	Very little grass.	Weevil.........	Small amount	100	87
2–1	Furrow...	Dunkirk gravelly loam	Grass, weeds, and briers	Weevil.........	4	500	93
2–1	Furrow...	Dunkirk gravelly loam	Grass, weeds, and briers	....	....	200	95
2–2	Hole.....	Dunkirk sandy loam .	Moderate amount of grass	Weevil.........	Very little	300	98
2–2	Hole.....	Dunkirk sandy loam .	Moderate amount of grass	....	....	200	94
2–1	Hole.....	Dunkirk sandy loam.	Moderate amount of grass	Weevil.........	Very little	300	87
2–1	Hole.....	Dunkirk sandy loam.	Moderate amount of grass	....	....	200	91
2–1	Hole.....	Dunkirk sandy loam.	Moderate amount of grass	....	....	500	87
2–2	Hole.....	Dunkirk gravelly loam	Moderate amount of grass	Weevil.........	Very little	200	90
2–2	Hole.....	Dunkirk gravelly loam	Moderate amount of grass	Weevil.........	Very little	200	85
2–1	Hole.....	Dunkirk gravelly loam	Moderate amount of grass	Weevil.........	Very little	200	85
2–1	Hole.....	Dunkirk sandy loam .	Very little......	....	....	200	87
2–1	Hole.....	Dunkirk sandy loam .	Very little......	....	....	200	87
2–1	Hole.....	Dunkirk sandy loam .	None..........	....	....	500	70
2–1	Hole.....	Dunkirk sandy loam .	None..........	....	....	200	80
2–1	Furrow...	Dunkirk sandy loam .	None..........	....	....	200	98
2–1	Furrow...	Dunkirk sandy loam .	Grass..........	....	....	200	91
2–1	Hole.....	Dunkirk sandy loam .	Grass..........	....	....	500	65
2–1	Hole.....	Fox gravelly loam ...	Grass..........	Weevil.........	40	400	80
2–1	Hole.....	Dutchess stony loam .	Grass..........	Weevil.........	5	200	85
2–1	Hole.....	Dutchess stony loam .	....	Weevil.........	5	....	80

bed, and the second figure to the number of years they were in transplant rows.

HEIGHT GROWTH OF TREES

The average rate of height growth of trees in plantations is shown in table 4. Eliminating exceptional conditions of environment, such as competing vegetation, shade, or soils of a particular character, it has been found that the rate of height growth for a given species is dependent on the age of the plantation, the minimum temperatures of the locality, and the soil moisture available during the latter part of May and the month of June—the time at which the most rapid increase in height growth is made.

FIG. 120. WHITE PINE SHOWING ANNUAL HEIGHT GROWTH FOR 1912, 1913, AND 1914
The comparatively small growth for 1913 is due to less rainfall during the growing season

During the first few years in the life of a plantation, growth is necessarily slow. The trees have to recover from the shock of transportation and transplanting, and adapt themselves to new conditions. First, the roots must gain a good foothold, after which the rate in height growth should increase annually until the maximum rate has been attained.

There is a vast difference in the rate of growth of various species. Scotch pine will grow much more rapidly at first than white pine, and white pine will grow faster than spruce for a while. At the end of twenty-five or thirty years, however, under suitable conditions of growth for each species, the difference will not be so marked.

Other conditions being equal, the height growth of trees is influenced mostly by soil moisture and minimum temperatures during the growing season. The annual height growth for three years of a white pine tree in a plantation at Millbrook is shown in figure 120. The United States Weather Bureau Station located nearest this plantation gives the following figures for precipitation and minimum temperatures for the month of June during the three years.

Year	Rainfall (inches)	Minimum temperature (Fahrenheit)	Average annual height growth of trees (feet)
1914	2.39	42°	1.80
1913	1.72	41°	1.09
1912	1.11	44°	1.90

TABLE 4. HEIGHT GROWTH OF TREES IN PLANTATIONS

Plantation	Location	Planted by	Species	Year planted	Average annual height growth (in feet) 1914	1913	1912	1911	1910	1909	1908	Number of trees measured	Average total height (feet)
1	Hemlock Lake	Rochester Water Company	White pine	1901	1.80	1.86	1.72	1.65	.86	1.00	.75	25	12.92
1			Norway spruce	1901	2.00	2.06	1.25	1.25	1.14	.71	.57	15	8.85
2			White pine	1901	1.01	2.14	1.78	1.99	1.27	....	....	10	13.10
2			Norway spruce	1901	1.18	1.94	1.32	1.64	1.00	1.27	.96	10	15.10
3			White pine	1909	.94	1.08	.70	.50	.39	....	....	40	3.89
4	Cooperstown	Clark estate	White pine	1909	1.63	1.20	1.47	.88	....	....	....	26	6.27
5			White pine	1909	1.43	1.21	1.30	.55	....	....	....	62	5.89
6			White pine	1909	1.68	1.30	1.50	.77	....	....	....	73	6.33
7	Norwich	Norwich Cemetery Association	Scotch pine	1910	1.35	1.07	1.09	.59	....	....	....	30	4.58
8			Norway spruce	1910	1.27	.57	.51	....	....	....	....	30	3.58
9			White pine	1912	.57	.37	....	....	....	....	....	20	1.54
10		Norwich Water Company	White pine	1912	1.01	.52	....	....	....	....	....	50	2.02
11			Norway spruce	1912	.92	.43	....	....	....	....	....	26	1.90
12	Waverly	A. G. DuBois	White pine	1909	.61	.60	.68	.49	.28	....	....	40	3.04
13	Fulton	Great Bear Spring Water Company	Scotch pine	1907	2.77	2.48	1.97	1.30	1.17	....	....	30	11.01
14			Scotch pine	1909	2.41	1.91	1.40	.96	....	....	....	30	7.72
15			White pine	1909	2.02	1.97	1.58	1.15	....	....	....	34	7.71
16			White pine	1909	1.27	1.76	1.25	.90	....	....	....	75	6.06
18	Gloversville	Gloversville Water Company	White pine	1908	1.89	1.76	1.26	1.32	1.12	....	....	30	8.92
19			Scotch pine	1908	2.00	1.51	1.31	1.07	1.05	....	....	20	8.43
20			White pine	1909	1.60	1.35	1.00	.80	....	....	....	55	5.85
21			Scotch pine	1910	1.38	.97	.82	.65	....	....	....	20	4.72
23		J. Wood	White pine	1908	1.41	.92	.93	.82	.56	....	....	20	6.26
24			White pine	1909	1.08	.74	.64	....	....	....	....	20	4.07
25			White pine	1909	1.39	.94	1.55	....	....	....	....	20	4.95
26	Johnstown	David A. Hays	Scotch pine	1909	1.74	1.00	1.02	....	....	....	....	20	5.55
27			Scotch pine	1910	1.47	.78	.82	....	....	....	....	20	4.26
31		Johnstown Water Company	Scotch pine	1910	1.49	.87	.85	....	....	....	....	20	4.87
33	Millbrook	Oakleigh Thorne	White pine	1909	1.80	1.09	1.90	.99	....	....	....	60	6.96
34	Hyde Park	A. Rogers	White pine	1909	1.35	1.04	1.36	1.22	....	....	....	20	6.15
35			White pine	1909	1.36	1.32	1.13	1.02	....	....	....	20	5.95

VALUE OF YOUNG PLANTATIONS

At present there is a growing tendency toward giving to land supporting immature stands of valuable tree species, of either natural or planted growth, an increased value because of the presence of the young growth of timber. Immature stands of native white pine in the New England States are being purchased and held awaiting their development into merchantable timber. E. C. Hirst, State Forester of New Hampshire, writes as follows: "I have in mind one tract of land that sold for sixteen dollars per acre. The bare land would probably have been worth six to eight dollars, but there was a growth of pines on the ground all the way from small seedlings to saplings twenty feet high, and this is what made the extra value." B. H. Chandler, Assistant State Forester of Vermont, writes in a recent letter: "In buying land for the State we always take into consideration the young growth when making up our estimate of land values. I consider a fully stocked reproduction of valuable fast-growing species on I or II quality soil worth about ten dollars per acre in addition to the value of the land."

These examples of the value attached to young stands of natural growth will serve as an index to the value to be placed on young planted forests. No instance is on record of the sale of a young forest plantation, and for this reason figures for actual increase in value of land due to reforesting are not available at this time.

YIELDS OF OLDER PLANTATIONS

Only a few New York plantations are old enough to give an accurate idea of the yields that may be obtained by reforesting non-agricultural lands. Twenty-two sample plots in plantations at Millbrook and at White Lake Corners, in stands ranging in age from fifteen to forty-four years, were measured, and the yields are discussed in the following pages.

PLANTATIONS OF C. F. DIETRICH, MILLBROOK, NEW YORK

The plantations of C. F. Dietrich are on his estate, one and one-half miles east of Millbrook. They are situated on the slopes of two ridges, which are separated by a small stream flowing in a westerly direction. The ridge on the north side of the creek is high, with a very steep slope, thin soil, and a great many rocks and bowlders on the surface; while the ridge on the south side is much lower, with a gentle to medium slope, and a much smaller quantity of rocks and stones except on the very crest of the ridge. The soil types are the Dutchess slate loam at the higher elevations, grading into the Dutchess silt loam at the lower elevations. The most noticeable differences in the two types are in the depth of the soil and the quantity of loose stones and exposed rock surface. The slate loam

FIG. 121. NORWAY SPRUCE PLANTATION ON SHALLOW, STONY SOIL, NEAR MILLBROOK, DUTCHESS COUNTY
Age, 18 years; average height, 30 feet; average diameter, 4 inches

FIG. 122. WHITE PINE PLANTATION NEAR MILLBROOK

Age, 15 years; average height, 25 feet; average diameter, 4.3 inches; maximum diameter, 7 inches

FIG. 123. PLANTATION OF EUROPEAN LARCH NEAR MILLBROOK

Age, 22 years; average height, 30 feet; average diameter, 4 inches; maximum diameter, 7 inches

type is very shallow and stony, while the silt loam is deep and fairly free from large stones.

The older plantations, comprising over a hundred acres planted to norway spruce, white pine, scotch pine, and European larch (Figs. 121, 122, and 123), range in age from fifteen to twenty-five years and were made with three-years-old transplants imported from Germany.

The spacing of the trees in all the plantations is much closer than is the common practice at the present time. As a result of this close spacing all the stands are very densely stocked. No thinning has been done except to remove trees that have died because of their inability to withstand the great competition for light and moisture. In many of the stands the lower branches, to a height of seven or eight feet, were pruned off after they had been killed by the overhead shade.

The trees are all straight and have made fairly rapid height growth. The diameter growth has been somewhat checked by the crowded condition of the stands. This is proved by the fact that the trees on the edges of openings and on the outer borders of plantations are larger in diameter than those in the midst of the plantations.

Two soil qualities are recognized for these plantations. They are based on average height and diameter growth of the trees, and conform very closely to the dividing line between the two types of soil as mentioned on page 674. All species have made the best growth on the lower slopes, but the difference in rate of growth for the different situations is not so great for some species as for others.

Each of the sample plots measured was one-tenth acre in extent. The plots were selected in the most uniform parts of the plantations. Diameter measurements were taken at a point four and one-half feet from the ground, with a diameter tape that was read to the nearest inch. Height measurements were taken with a Goulier hypsometer. All the information collected from the various sample plots (including stand tables, basal areas, and estimated yields) is presented in tabular form in tables 5 and 6.

PLANTATIONS OF T. DALLARME, WHITE LAKE CORNERS, NEW YORK

The plantations made by the late T. Dallarme are located on his farm, bordering the shores of Round Lake, four miles from White Lake, New York. The slopes of Round Lake are irregular and are characterized by sandy knolls and ridges. The soil is all of a sandy nature and does not hold moisture well.

Mr. Dallarme first took possession of this farm in 1856. Most of the original forest had been destroyed by fires, and Mr. Dallarme cleared the land and used it for the production of agricultural crops. After being farmed for fifteen or twenty years the soil on the tops of the sandy ridges and knolls bordering the northern shore of the lake became too poor to

TABLE 5. DATA OF SAMPLE PLOTS IN THE PLANTATIONS OF C. F. DIETRICH, MILLBROOK, NEW YORK

Plot	Species	Spacing (feet)	Age (years)	Average height (feet)	Number of trees in diameter inch classes per plot: 2	3	4	5	6	7	8	9	Number of trees per species	Average diameter per species (inches)	Total number of trees per plot
1	Norway spruce	4 x 4	18	30	15	18	62	45	5	....	....	....	......	3.8	145
2	Norway spruce	4 x 4	18	30	13	29	55	34	4	....	....	....	......	3.9	135
3	Norway spruce	3 x 5	18	32	37	75	50	22	3	....	....	....	......	3.3	187
4	Norway spruce	3 x 4	22	40	6	37	50	41	8	1	....	....	......	4.0	143
5	White pine	4 x 4	15	28	11	27	28	33	19	5	....	....	......	4.3	123
6	White pine	4 x 4	15	28	13	36	45	37	14	1	....	....	......	4.0	146
7	White pine	4 x 4	15	25	17	44	43	26	2	....	....	....	......	3.6	132
8	White pine	Irregular	18	22	59	69	57	27	9	....	....	....	221	3.3	226
	Scotch pine	Irregular	18	22	1	....	3	1	....	....	....	....	5	3.8	
9	Norway spruce	3 x 6	18	28	10	32	48	21	3	....	....	....	114	3.7	177
	White pine	3 x 6	18	25	12	24	21	5	1	....	....	....	63	3.3	
10	Scotch pine	3 x 4	22	35	54	62	35	13	3	1	....	....	......	3.1	168
11	Scotch pine	3 x 5	22	33	10	53	56	38	22	4	....	....	......	4.1	183
12	Scotch pine	3 x 5	22	42	3	27	48	31	20	15	5	1	......	4.7	150
13	Scotch pine	3 x 6	25	35	2	9	14	20	18	10	4	1	78	5.2	109
	Larch				4	7	9	7	4	....	....	....	31	4.0	
14	Norway spruce	3 x 4	22	37	16	11	2	....	....	....	....	....	29	2.5	151
	Larch				19	35	36	20	8	3	1	....	122	3.8	
15	Larch	3 x 6	22	30	9	16	26	25	5	1	....	....	82	4.0	106
	White pine				10	4	6	....	....	....	....	....	20	2.8	
	Scotch pine				...	....	....	3	1	....	....	....	4	5.2	

TABLE 6. YIELDS OF SAMPLE PLOTS IN THE PLANTATIONS OF C. F. DIETRICH, MILLBROOK, NEW YORK

Plot	Species	Age (years)	Average height (feet)	Number of trees per acre	Average diameter per plot (inches)	Soil type	Soil quality	Yield per acre
1	Norway spruce	18	30	1,460	3.8	Dutchess silt loam	I	2,064 cu. ft.*
2	Norway spruce	18	30	1,330	3.9	Dutchess silt loam	I	1,792 cu. ft.
3	Norway spruce	18	32	1,870	3.3	Dutchess slate loam	III	1,823 cu. ft.
4	Norway spruce	22	40	1,430	4.0	Dutchess slate loam	III	3,107 cu. ft.
5	White pine	15	28	1,230	4.3	Dutchess slate loam	I	7,410 bd. ft.†
6	White pine	15	28	1,460	4.0	Dutchess slate loam	I	7,210 bd. ft.
7	White pine	15	25	1,320	3.6	Dutchess slate loam	III	4,410 bd. ft.
8	White pine Scotch pine	18	22	2,260	3.3	Dutchess slate loam	III	4,980 bd. ft.
9	Norway spruce White pine	18 18	28 25	1,770	3.5	Dutchess slate loam	III	2,263 cu. ft.
10	Scotch pine	22	35	1,680	3.1	Dutchess slate loam	III	1,590 cu. ft.
11	Scotch pine	22	33	1,830	4.1	Dutchess slate loam	III	3,041 cu. ft.
12	Scotch pine	22	42	1,500	4.7	Dutchess slate loam	I	3,367 cu. ft.
13	Scotch pine Larch	25	35	1,090	4.8	....	I	2,600 cu. ft.
14	Norway spruce Larch	22	37	1,510	3.5	....	III	2,630 cu. ft.
15	Larch White pine Scotch pine	22	30	1,060	3.8	....	III	1,420 cu. ft.

* Cubic-feet volumes adapted from normal yield tables by Adam Schwappach.
† Board-feet volumes taken from *The Woodsman's Handbook*, by Henry S. Graves and E. A. Ziegler. U. S. Forest Service. Bul. 36: 124. 1911.

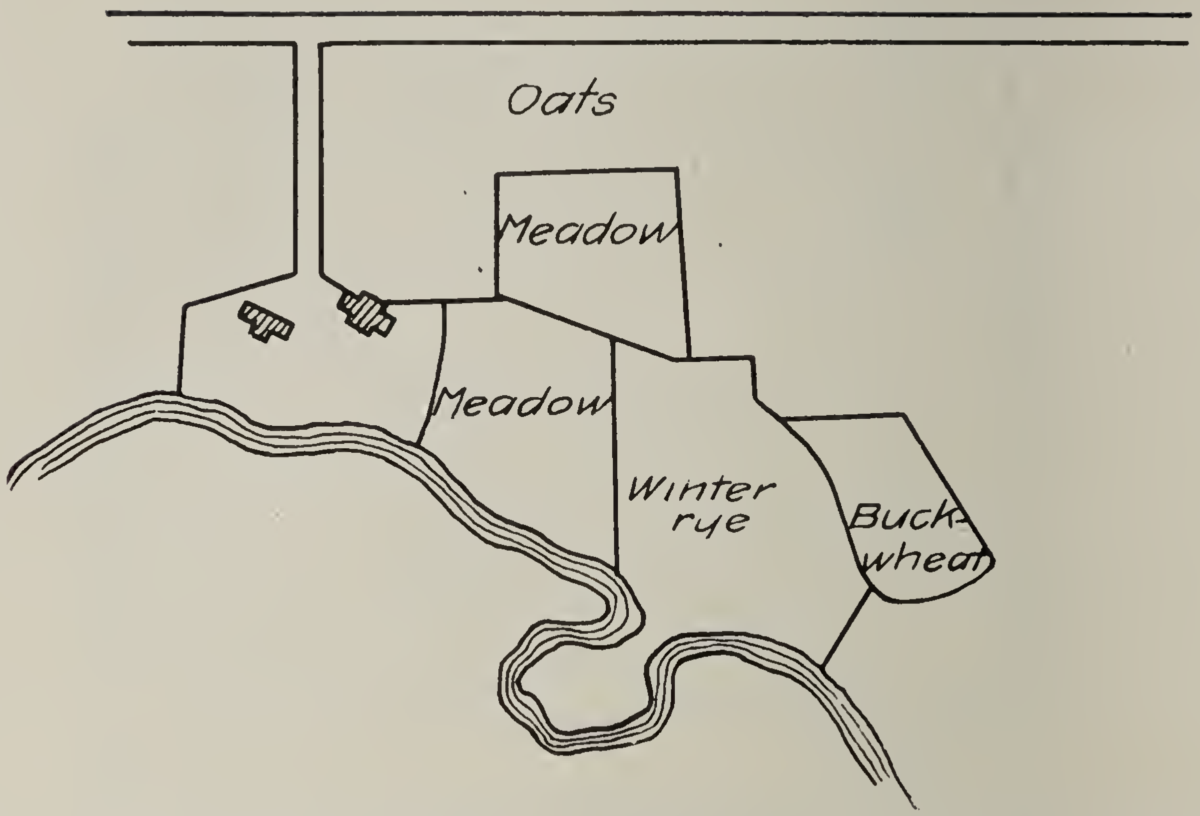

FIG. 124. SKETCH MAP OF DALLARME FARM SHOWING CROPS RAISED AND ARRANGEMENT OF FIELDS IN 1859

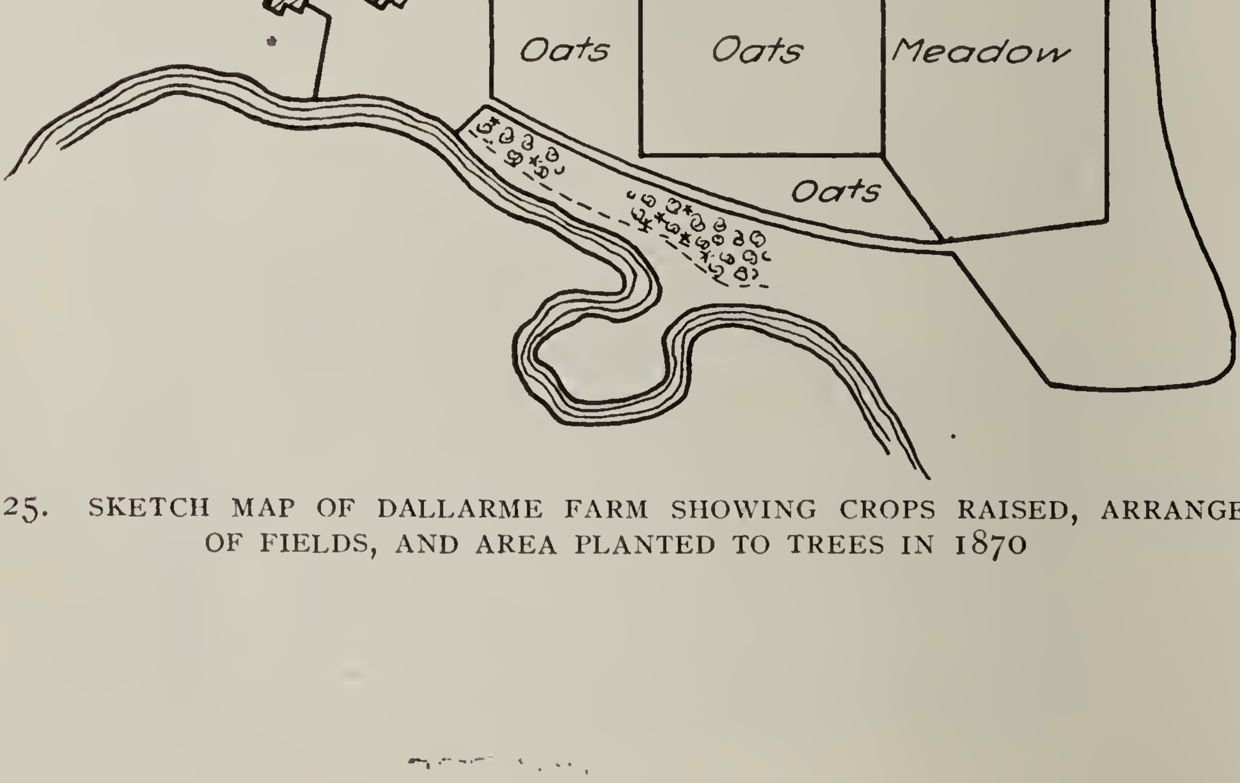

FIG. 125. SKETCH MAP OF DALLARME FARM SHOWING CROPS RAISED, ARRANGEMENT OF FIELDS, AND AREA PLANTED TO TREES IN 1870

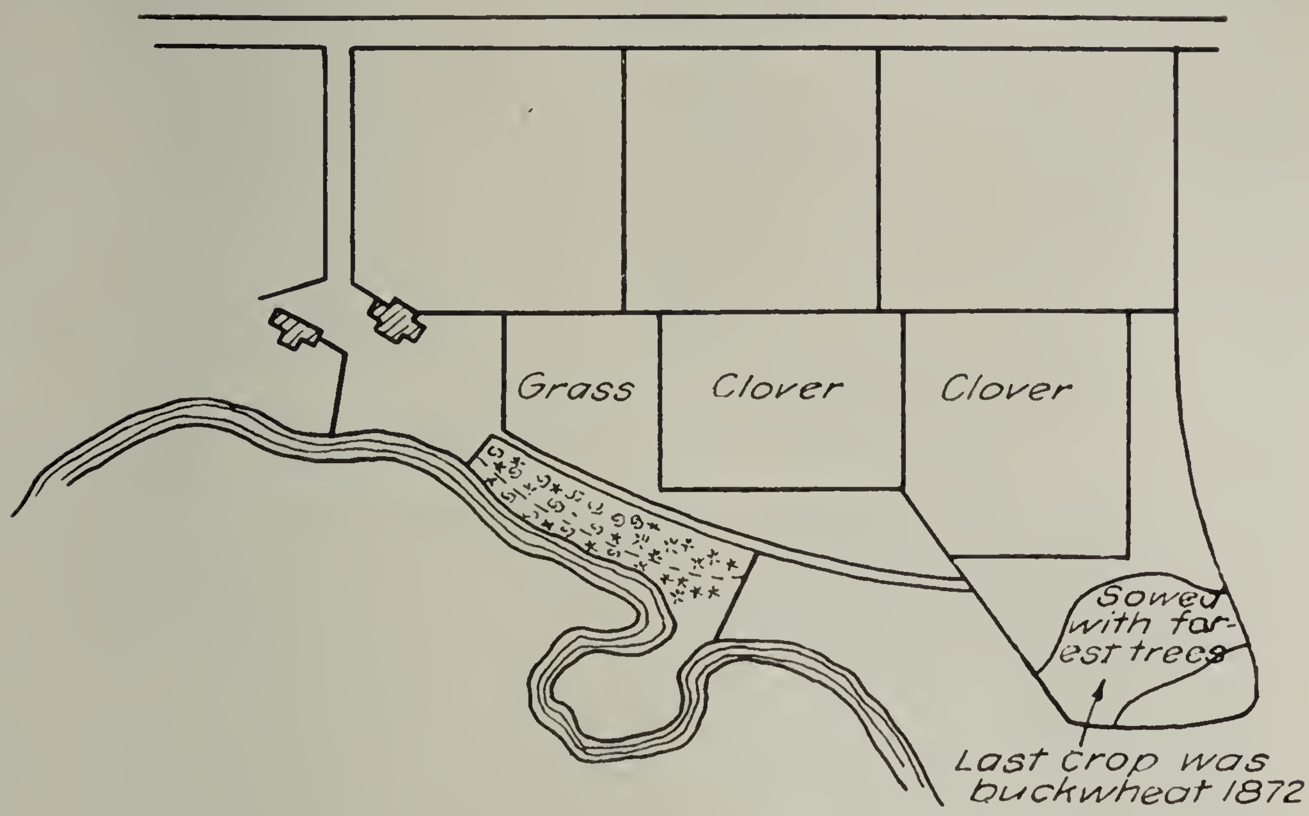

FIG. 126. SKETCH MAP OF DALLARME FARM SHOWING CROPS RAISED, ARRANGEMENT OF FIELDS, AND AREA SEEDED TO FOREST TREE SEEDS IN 1874

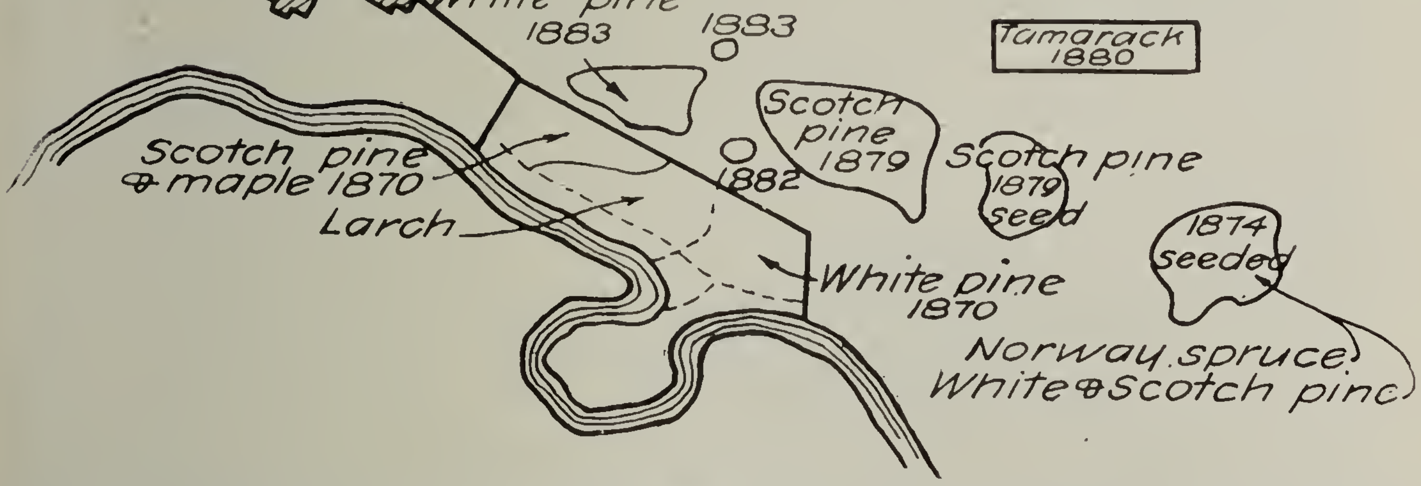

FIG. 127. SKETCH MAP OF DALLARME FARM SHOWING AREAS PLANTED TO TREES IN 1883 AND LOCATION OF ALL THE OLDER PLANTATIONS ON THE FARM

produce satisfactory crops. It was then that Mr. Dallarme brought tree seeds and young trees from Germany and began the work of reforesting these areas, which could no longer be cultivated at a profit.

Mr. Dallarme kept a very accurate and detailed record of all the work done on his farm. This record included sketch maps showing all the tilled parts of the farm, the arrangement of the fields, and the crops grown in them. These maps are available for each year from 1857 until 1894. A few of them (Figs. 124 to 127) have been reproduced here in order to show the use to which the land had been put, and the crops grown, previous to the time of the reforestation of the various tracts.

FIG. 128. EXTERIOR VIEW OF WHITE PINE PLANTATION AT WHITE LAKE, NEW YORK, FORTY-FOUR YEARS OLD

The first planting was done by Mr. Dallarme in 1870, with white pine, European larch, scotch pine, and sugar maple. These species were planted in small groups along the northern shore of the lake, on land that had been used for pasture from 1860 to 1869. The object of this planting was more for the sake of the additional beauty that the trees gave to the rather steep shore of the lake, than for their value for other purposes. The white pine group (Figs. 128 and 129) was the most extensive, and, while it does not at present show a fully stocked stand of white pine since there are several other species present, yet it presents a very valuable illustration of the development to be expected from plantations of white pine in New York State, the present yield being 38,610 board feet per acre.

Fig. 129. Plantation of White Pine at White Lake
Age, 44 years; average height, 60 feet; average diameter, 13.5 inches; maximum diameter, 19 inches; yield, 38,500 board feet per acre

The next area to be reforested was the top of a sandy knoll near the northern shore of the lake. On the map of Mr. Dallarme's farm for the year 1874 this area is indicated as being sown to forest tree seeds. The resulting stand consists of a mixture of norway spruce, scotch pine, and white pine, in which the spruce is the predominating species. The present total yield per acre in this stand is 7770 cubic feet, or an equivalent of 35,000 board feet, per acre. This stand presents an excellent example of the results of reforestation on land too poor to produce agricultural crops. The annual maps made by Mr. Dallarme show that this area had been under cultivation for twenty-two years.

Mr. Dallarme continued his planting at intervals of a few years, the next being done in 1879, when another small area was sown with scotch pine seeds and an adjacent knoll was planted with the same species. These trees have now attained an average height of fifty feet, an average diameter of eight and one-half inches, and a total yield of 6775 cubic feet, or 30,000 board feet, per acre.

In 1880 a small area higher on the slope, which had been planted to potatoes the previous year, was planted to larch. This plantation has not developed very well, owing to the dry, sandy character of the soil, which gives ready natural drainage, and to the higher elevation.

In 1883 the tops of two sandy knolls were planted to white pine. These areas had been in grass for seven years prior to 1881, when they were plowed and again seeded with grass. The result must have been poor, as no crop is indicated for 1882. The present production on these areas is 18,440 board feet per acre.

All the planting done by Mr. Dallarme was confined to areas which either did not produce satisfactory crops or were unsuited for cultivation owing to the character of the ground. After the establishment of a forest growth on these areas the better soils between them were still cultivated (Fig. 127, sketch map for 1883). The areas planted to trees had previously produced crops of hay, oats, rye, clover, potatoes, cabbage, and millet.

Although the Dallarme plantations are not extensive — the total area covered is not more than fifteen acres — their chief value lies in their importance as a direct demonstration of the results that may be obtained in reforesting worn-out and denuded lands in this State. This land was taken by Mr. Dallarme in a devastated condition. He cleared the ground, used it for production of crops as long as it maintained its productivity, and then restored its forest cover, which at the time of his death had developed a stand of timber of greater value than the stand he first found there.

The data concerning the Dallarme plantations are given in tables 7 and 8.

FIG. 130. SCOTCH PINE PLANTATION AT WHITE LAKE, NEW YORK
Age, 35 years; average height, 50 feet; average diameter, 8.6 inches; maximum diameter, 14 inches

TABLE 7. DATA OF SAMPLE PLOTS IN THE PLANTATION OF T. DALLARME, WHITE LAKE, NEW YORK

Plot	Species	Age (years)	Average height (feet)	Area of plot (acres)	Number of trees in diameter inch classes per plot																Number of trees per species	Average diameter per species (inches)	Total number of trees per plot
					4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
16..	White pine.........	31	45	0.100	18	10	14	14	12	6	2	...	...	...	...	...	...	...	...	...	......	6.2	76
17..	White pine.......	44	60	0.121	....	1	....	2	2	....	5	4	2	3	3	3	...	1	1	1	28	13.5	49
	Scotch pine.......				....	....	....	....	....	2	2	...	...	...	...	...	...	...	...	...	4	9.2	
	Norway spruce....				....	1	2	2	....	....	....	...	...	...	...	...	...	...	...	...	5	6.2	
	Balsam fir........				....	....	....	....	2	1	1	...	...	...	...	...	...	...	...	...	4	7.0	
	Larch............				....	2	1	1	1	....	2	1	...	...	...	...	...	...	...	...	8	7.7	
18..	Larch.............	44	55	0.045	....	2	1	1	5	9	....	...	1	...	1	1	...	...	...	...	......	8.7	21
19..	Norway spruce....	40	55	0.100	10	6	8	7	4	2	5	1	...	...	...	...	...	...	...	...	43	6.5	62
	Scotch pine.......				....	2	1	1	3	1	2	2	...	2	2	...	...	...	...	...	16	9.5	
	White pine.......				....	1	....	1	1	....	....	...	...	...	...	...	...	...	...	...	3	7.5	
20..	Norway spruce....	40	55	0.100	7	10	12	5	7	3	4	2	...	...	...	...	...	...	...	...	50	7.7	65
	Scotch pine.......				2	2	2	1	1	....	2	1	...	1	2	...	...	...	...	...	14	8.3	
	White pine.......				....	....	....	....	....	....	....	...	1	...	...	...	...	...	...	...	1	12.0	
21..	Scotch pine.......	35	50	0.100	....	....	13	8	13	11	7	5	5	1	2	...	...	...	...	...	65	8.6	74
	White pine.......				....	....	1	4	3	....	1	...	...	...	...	...	...	...	...	...	9	8.5	
22..	Scotch pine.........	35	50	0.100	....	9	4	4	10	17	11	4	...	2	...	...	...	...	...	...	......	8.5	61

TABLE 8. YIELDS OF SAMPLE PLOTS IN THE PLANTATION OF T. DALLARME, WHITE LAKE, NEW YORK

Plot	Species	Age (years)	Average height (feet)	Number of trees per acre	Average diameter per plot (inches)	Soil type	Soil quality	Yield per acre
16	White pine	31	45	760	6.2	Adirondack stony loam	I	18,440 bd. ft.*
17	White pine Scotch pine Norway spruce Balsam fir Larch	44	60	408	10.0	Adirondack stony loam	I	38,610 bd. ft.
18	Larch	44	55	945	8.7	Adirondack stony loam	I	6,640 cu. ft.†
19	Norway spruce Scotch pine White pine	40	55	630	7.3	Adirondack stony loam	I	7,770 cu. ft.
20	Norway spruce Scotch pine White pine	40	55	650	6.7	Adirondack stony loam	I	5,167 cu. ft.
21	Scotch pine White pine	35	50	730	8.6	Adirondack stony loam	I	6,775 cu. ft.
22	Scotch pine	35	50	610	8.5	Adirondack stony loam	I	5,419 cu. ft.

* Board-feet volumes taken from *The Woodsman's Handbook*, by Henry S. Graves and E. A. Ziegler. U. S. Forest Service. Bul. 36: 124. 1911.
† Cubic-feet volumes adapted from normal yield tables by Adam Schwappach.

CAUSES OF INJURY TO PLANTATIONS

INSECTS

WHITE PINE WEEVIL

The white pine weevil (*Pissodes strobi* Peck) has caused greater damage to white pine plantations than any other agent. In one plantation forty per cent of the trees have been injured by this insect. It is present in all plantations of white pine from five to fifteen years old, though usually not affecting more than ten per cent of the trees. Norway spruce planted in mixture with white pine at Hemlock Lake was found to be badly damaged, and the insect was also found in scotch pine at Johnstown.[4]

The insect is described by Felt [5] as an oblong, oval weevil about one-fourth of an inch long, which deposits its eggs in the leading shoots of the white pine or other evergreen trees. The grubs work in the shoots and kill them, causing the development of an irregularly deformed tree of very little commercial value. The adult beetle is from reddish brown to very dark brown in color, with a whitish spot near the posterior third of each wing cover. The creamy white pupa is of about the same length as the beetle. The grub is a white, footless creature, varying in size according to the stage of development.

The beetles are most abundant in the spring, when the eggs are deposited on the leading shoots of the pine. The grub, on hatching, eats its way obliquely inward and downward until it reaches the pith, in which it burrows for a short distance. The shoot continues its growth until about the middle of July, when it begins to wilt as a result of the injury caused by the grub. Examination of the shoot reveals small oval cells, each containing a plump white larva, or grub, which later changes to a pupa. The adult beetles appear in the fall and hibernate.

Dr. W. E. Britton and B. H. Walden [6] made some preliminary tests on the control of the white pine weevil. According to their report the insects spend the winter on the ground, under pine needles, the beetles appearing on the leaders of the pine trees about the first of May.

The materials used in these tests were solutions of lead arsenate, commercial lime-sulfur, " One-for-all," whale-oil soap, and tree tanglefoot. Out of forty-five trees treated, only five were attacked by the weevil; while out of ten trees left as a check, six leaders were killed. The " One-for-all " was found to be injurious to the leaders of the trees, the tree tanglefoot was found difficult to use, and not enough trees were sprayed

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[4] Affected specimens of norway spruce and scotch pine from Hemlock Lake and from Johnstown were brought to the Department of Entomology at this College, and the insect causing the damage was identified as *Pissodes strobi* in both cases.

[5] Felt, E. P. Insects affecting park and woodland trees. New York State Museum. Memoir 8:2:397-401. 1906.

[6] Britton, W. E., and Walden, B. H. Record of preliminary tests to prevent damage by the white pine weevil. Connecticut Agr. Exp. Sta. Ann. rept. 35 (1911):307-309. 1912.

with the lime-sulfur to draw any conclusions; the lead arsenate and the whale-oil soap showed very satisfactory results. The question of cost of application is the main feature in considering any of these methods for control of the insect.

The remedial measures in common practice for the control of the white pine weevil are to cut out the leaders and burn them as soon as the presence of the insect manifests itself; placing the leaders in a barrel and covering them with a wire gauze too small to prevent the escape of the beetles has been recommended in order to allow any parasite that may be present with the insects to escape and fly back to the pine trees. On the Clark estate at Cooperstown the beetles were caught in nets when they appeared on the plantations in May, and later all affected leaders were pruned off and burned immediately.

LOCUST BORER

The work of the locust borer (*Cyllene robiniae* Forst.) [7] on native black locusts is characterized by ugly, irregular scars, which open into burrows about one-fourth inch in diameter. The beetle is black, prettily marked with gold and yellow, and less than three-fourths of an inch long, and in the fall the insects may be found on goldenrod in considerable numbers.

The beetles gather on locust trees in September and deposit their eggs in the crevices of the bark. The eggs are soon hatched and the grubs burrow immediately into the bark, devouring the soft inner substance, which suffices for their nourishment until the approach of winter. They pass the winter just beneath the outside corky bark, in a torpid state. In spring they bore through the sapwood more or less deeply into the trunk of the tree. The seat of their operations is known by the oozing of the sap and the dropping of sawdust from the holes. The bark around the part attacked begins to swell, and in a few years the trunks and the limbs become disfigured by large porous tumors. The grubs attain their full size by the twentieth of July and soon become pupæ. In September they are transformed into beetles and leave the tree.

The work of the locust borer is very destructive in parts of New York State. Its presence practically prevents the planting of black locust in certain sections, thus limiting the use of one of the most thrifty and vigorous of trees.

The overwintering larvæ may be destroyed by spraying the trunks of trees with a twenty-per-cent kerosene emulsion. The trees should be sprayed either in the late fall, after November 1, or in the spring, not later than April 1.

[7] Felt, E. P. Insects affecting park and woodland trees. New York State Museum. Memoir 8: 1: 93–97. 1905.

WHITE PINE BLISTER RUST

In a few of the 1909 plantations made with stock imported from Europe, white pine blister rust has been found on some of the trees, and it has been necessary to inspect these plantations annually in order to keep the disease in check.

White pine blister rust (*Peridermium strobi* Klebahn)[8] is recognized by a stunted growth of the trees and later the development of swellings, or cankers, at the base. Longitudinal cracks appear in these cankers, from which drops of liquid exude, and large clumps of orange-yellow pustules burst through the bark in places. The disease is caused by the aecial stage of the fungus *Cronartium ribicola* Fisch. de Waldh. The uredinial and telial stages appear on species of the genus Ribes, which includes the currants and the gooseberries. Aeciospores produced in the blisters on the pine can infect the leaves of currants and gooseberries and there produce the urediniospores which serve to spread the fungus rapidly from one plant to another. Later in the fall teliospores are produced on hornlike growths on the underside of the leaves. These spores germinate, producing sporidia which may infect young growth on white pines. The swelling of the pine bark appears in from one to several years after infection. A peculiar characteristic of this disease is that it cannot spread directly from one pine tree to another, but must pass through the stage on currants or gooseberries before it can infect pines.

The principal control measures for this disease if it is found in a plantation are: first, to burn all diseased trees or parts of trees found in the plantation; second, to remove all currant and gooseberry plants from the plantation and its near vicinity; and third, to inspect the plantation periodically, destroying all pine trees that show any evidence of the presence of the disease. European white pine has been excluded from this country, so that the only source of further infection must be from the present plantations made with European stock.

ANIMALS

RODENTS AND SMALL GAME

The amount of damage to forest plantations caused by small animals is usually comparatively small. Mice girdled a few trees in a black locust plantation at Ithaca, and in plantations of scotch pine and white pine at the same place a leader here and there has been nipped off, apparently the work of rabbits. The pieces bitten off were usually found by the side of the tree.

STOCK AND LARGE GAME

Where the grazing of stock is allowed in plantations, many trees are broken and trampled by the animals. In the plantation of white pine

[8] Spaulding, Perley. The blister rust of white pine. U. S. Plant Indus. Bur. Bul. 206:1–88. 1911.

and norway spruce at the upper end of Hemlock Lake, there are many large open spaces resulting from the use of the ground for grazing after the trees had been planted.

Large game animals, such as deer, often do great damage to plantations by browsing the leading shoots and branches. One owner in the Adirondacks reports that twenty-five per cent of the trees in his plantation had the leaders bitten off by deer during one winter.

CLIMATIC AGENTS

Damage by storms and other climatic agents cannot be avoided, but usually such damage is not extensive. Snow and ice are the most destructive climatic agents to young and immature stands.

FIG. 131. LOWER BRANCHES OF YOUNG TREES BENT DOWN BY SNOW PRESSURE
Plantation of A. Rogers, Hyde Park

Snowbreak occurred in a stand of European larch at Millbrook on November 20, 1914, as a result of a fall of six inches of snow, which weighed down the branches so heavily that the top of one tree was broken off completely. The break was at a point three or four inches in diameter and twenty feet above the ground. Broken branches resulting from snowbreak were seen also in the scotch pine stands at White Lake.

Snowbreak may occur when snow becomes drifted about the lower branches of trees in young plantations and then settles, causing the branches to be bent down. This is shown in the accompanying illustration of a plantation at Hyde Park (Fig. 131).

In very young plantations a whole tree is often bent to the ground by the pressure of snow, but in most cases the tree straightens itself again except for a slight crook near the surface of the ground.

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AGRICULTURAL EXPERIMENT STATION OF THE
NEW YORK STATE COLLEGE OF AGRICULTURE
BEVERLY T. GALLOWAY, Director
Department of Forestry

POSSIBILITIES OF PRIVATE FOREST MANAGEMENT IN NEW YORK STATE

CEDRIC H. GUISE

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The regular bulletins of the Station are sent free on request to residents of New York State.

CONTENTS

POSSIBILITIES OF PRIVATE FOREST MANAGEMENT IN NEW YORK STATE[1]

CEDRIC H. GUISE

INTRODUCTION

During the past decade much has been said and written relative to the practice of forestry by private interests. More often than otherwise such discussions have merely been presented in the form of popular articles and bulletins, with but little data, such as a prospective investor requires, to furnish proof of the writers' contentions. Invariably these arguments are highly favorable for inducing private investors to undertake and practice scientific forestry.

The rates of interest earned on investments of such a nature are seldom given, and it is information on just this point that a careful investor demands. In this bulletin the attempt is made to show what rates of interest, under average conditions, may be obtained on investments in different classes of timber suitable to management in New York State. In addition there are given brief discussions of silvicultural possibilities in regard to market, taxes, and fire risks, and, in short, to all salient factors which directly concern the growing of timber and on which returns on the investments directly depend. No effort has been made to obtain results favorable to forestry undertaking. Only those results that can in all probability be actually realized have been worked for.

In this work the need of yield tables for species of trees suitable to forest management in this State becomes very apparent. Particularly are such tables needed for norway spruce and norway pine. The reason for not using European yield tables is that these take into account the returns from thinnings, and in this State financial returns from thinnings are so uncertain that it is not worth while to spend time and effort in calculating them.

Some of the more important reasons why forest production should be undertaken by public rather than private enterprise are as follows:

1. A higher rate of interest is required on private than on public undertakings.

2. The average business life of an individual is shorter than the period required to produce a forest crop.

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[1] Acknowledgment is made to Professor A. B. Recknagel for suggestions given and for aid in the preparation of this bulletin.

The subject of reforesting methods and results of forest planting in New York State is discussed in Bulletin 374 of this station.

3. Private enterprise depends for its existence solely on profits, while public enterprise includes certain benefits to the community.

4. In many cases the land is already the property of a state or a nation and no initial cost for this nor interest on it need be figured.

5. Public forestry can be conducted on a much larger scale than can private forestry, with resulting economy in all measures of protection, technical administration, and improved efficiency.

The material presented under the heading *Probable Yields* (page 716) covers the financial possibilities of forest management. The conclusions drawn from these yields are correlated with the points just discussed, and show under what conditions it is possible and feasible for the private investor to undertake the growing of timber.

THE PRESENT CONDITION OF AFFAIRS IN NEW YORK STATE

CLASSIFICATION OF PRIVATE HOLDINGS

Within the boundaries of the State of New York some 34,000,000 acres are included, of which 12,000,000 acres are in woodland. The bulk of state-owned land lies within the Adirondack and Catskill preserves. These preserves are situated in parts of sixteen counties, consist of nearly seven thousand scattered parcels, are bounded by almost nine thousand miles of line, and are intermixed with over three times as large an area of private forest land. This private property is controlled by corporations, private clubs, associations, and individuals.

The total land owned by the State in these preserves amounts to over 1,821,000 acres and is distributed as follows:

	Acres
Adirondack preserves	1,710,015.72
Catskill preserves	111,598.65
Total	1,821,614.37

The bulk of the preserves are situated rather compactly within their respective Adirondack and Catskill regions, and are called parks. The "Blue Lines" surround these and enclose the following areas:

	Acres
Adirondack park	1,406,899.36
Catskill park	101,437.64
Total	1,508,337.00

Thus, about 313,277 acres lie in the preserves outside of the parks.

The amount of land in the Adirondack and Catskill regions, the area of the state preserves in each, and the proportion of state and of private land in each, are shown approximately in table 1:

TABLE 1. PROPORTION OF STATE LAND AND OF PRIVATE LAND IN ADIRONDACK AND CATSKILL PRESERVES

	Area of region (acres)	Area of preserves (acres)	Percentage owned by State	Percentage owned by private interests
Adirondack	4,600,000	1,710,016	37	63
Catskill	1,200,000	111,599	9	91
Total	5,800,000	1,821,615	31	69

There has never been a thorough examination of the state lands for the purpose of obtaining reliable data as to the quantity of timber growing thereon. Some of the most recent and reliable estimates place the stumpage on state lands as 12,000,000,000 board feet, and on privately owned lands as double that.

These figures, and the figures in table 1, show vividly that private interests hold and control a much greater amount of both land and standing timber than does the State. It is obvious that if this ratio is to exist in the future, possibilities of forestry management on private timberland will certainly be investigated thoroughly.

Of the large area of forest land in the State, about 12,000,000 acres, approximately 4,500,000 acres are in woodlots too small to be brought under forest management with a purpose of sustained yield. The remaining privately owned forest lands are in parcels of varying sizes, but many of these tracts contain thousands of acres.

THE LAND AND ITS FORESTS

THE FOREST REGIONS OF NEW YORK STATE

Based on their characteristic location and topography, several forest regions stand out very clearly. A broad regional classification, with the approximate acreage and a brief description of each, follows.

THE ADIRONDACK REGION

Foremost of all is the Adirondack region, with its 4,600,000 acres. The topography (although generally rugged), the character of the land, and the forest growth, are as diversified as the distribution of the parcels of state and private land within the area. The extent of private holdings

is, on the average, large. Some paper and pulp companies have very extensive holdings. The climate is cold. On level land the soil is light and sandy; on slopes and uplands it becomes heavier. By its location and altitude, this must be classed as typical forest land. In past years fires have caused great losses, and large areas now exist which must be artificially restocked.

Forests of both conifers and hardwoods exist, varying in all degrees of mixture although some spruce is found almost everywhere. Red spruce is the predominant conifer, appearing pure or in a mixture with other conifers — hemlock, balsam, cedar, and pine — and hardwoods. Beech, birch, and maple are the chief associated hardwoods, with ash, black cherry, bird cherry, and the two poplars scattered about in mixture.

In the low swamps black spruce is the chief tree, being associated with balsam, cedar, and tamarack. This spruce is generally of small size. On the rather level and fairly well-drained flats above the swamps, red spruce appears and attains fairly good size, as does the hemlock mixed with it. Beech, birch, and maple begin to appear on these lands.

On the mountain slopes hardwoods predominate, and spruce also is found in considerable quantities. Excellent development is attained by the trees on these lands. The uppermost slopes, steep and rocky, with thin soils, bear the same spruce and hardwood mixtures, with the former reaching fairly large size. Spruce reproduction is quick to come in on openings. On southern slopes white pine is found. This is the big forest region of the State.

THE CATSKILL REGION

While the Adirondacks are covered largely with spruce and hardwoods in mixture, other areas of vast extent are characterized chiefly by the northern hardwood forests which they bear. The Catskills, with an area of close to 1,200,000 acres, rank first in these areas. The soils are well watered and generally fertile, although they contain a large amount of broken rock material. The climate is moderate.

The lower parts of the very narrow valleys are used for agriculture, but otherwise the entire country is covered with forests. Beech, birch, and maple, with scattering hemlock, basswood, and ash, form the predominant types of woodland on the lower ridges and ascend the slopes of the higher mountains. The reproduction of hardwoods is generally excellent. Formerly hemlock was of great importance, but practically all of this was removed several decades ago for the then abundant tanneries. On the higher slopes and the mountain tops, the hardwoods become more or less stunted and considerable balsam appears. This is not a spruce region. Swamps are rare. As an entire region, the Catskills offer an excellent situation for the application of forest management.

OTHER REGIONS

Several other regions bear a timber growth very similar to that of the Catskills. Among these are the Highlands of the Hudson, covering about 300,000 acres of rough, mountainous, rocky land in southeastern New York.

In the east central part of the State, west of the Catskills in Chenango and Otsego Counties, there are about 200,000 acres of such timber. The topography of this region is milder than that of the Catskills, and a larger proportion of the land is used for farming.

In the northern part of the Allegheny Mountain range is an area of almost 800,000 acres covered with typical hardwood forests. These are being extensively logged at present.

Other regions, with forests which are not characteristically beech, birch, and maple, nor spruce, are large enough to deserve special mention. In Oswego, Oneida, and Lewis Counties, in the north central part of the State, is a rough area of 250,000 acres where excellent forests of spruce, pine, and mixed hardwoods abound. The exploitation of the timber will no doubt soon begin here on an extensive scale. The Berkshire region, of approximately 150,000 acres, lies in a narrow belt in the Berkshires of New York. Birch, maple, chestnut, oak, and pine are the leading species, and white pine can, with management, be made to be the principal tree of this region. An excellent market exists here. There are about 400,000 acres of potential forest land on Long Island. In this region real estate speculations have produced many small holdings, a fact that will tend to discourage forest management for some time in the future. Eventually, should large estates take control of this land, forestry will be practiced here most intensively.

Woodlots, scattered over the entire State, cover about 4,500,000 acres. Most of these are small and in wretched shape, but in the aggregate they form a vast area. While intensive forestry can and should be applied to these, the majority of them are too small to be dealt with in the following discussion.

GROWTH AND PRESENT CONDITION OF FORESTS

Assuming that of the 12,000,000 acres of forested area in New York State 4,500,000 acres are in woodlots, this leaves a total of 7,500,000 acres in forests. Of this total about 6,000,000 acres bear saw timber, although only about 300,000 acres are in virgin timber. The remainder has been cut over more or less severely and averages about 4000 board feet to the acre.

With all this vast area, it is safe to assume that not over 1000 acres are producing more than one-half of the wood material which they should and could under proper management. In their present condition the woodlands

of the State are not producing more than 25 board feet per acre per year. For 12,000,000 acres this means 300,000,000 board feet produced annually. The annual cut is close to 1,000,000,000 board feet — over three times the amount grown; and, beyond this amount, vast quantities are imported every year from other States. At the present rate of consumption, the wood supply of this State will be exhausted in less than twenty-five years.

The thing to be considered, however, is not that twenty-five years hence it will suddenly be found that there is no timber. The economic laws of supply and demand will regulate this. But it is very obvious that prices will ascend by leaps and bounds during the next few decades, and that the present rate of consumption of wood will be greatly decreased.

MARKET CONDITIONS

PRESENT CONDITIONS AND FUTURE OUTLOOK

Fifty years ago New York led all States in the production of timber. To-day she ranks twenty-third. This rapid decline as a timber-producing State has been accompanied by a relative increase in her demand for forest products. New York is to-day the greatest wood-consuming State in the Union, using annually over 2,000,000,000 board feet of lumber in her wood-using industries. About one-third of this amount comes from her own forests; each year $100,000,000 is sent out of the State for forest products which could just as well be grown on her own lands, now idle and unproductive. Practically every foot of the New York sawmill output is used by local wood-using establishments, while much additional wood goes to the factory in the form of logs.

White pine is used to a greater extent and for a greater variety of products than any other class of wood. Other woods in order of their importance are spruce, white oak, southern pine, hard maple, chestnut, and so on. Large quantities of redwood and douglas fir from the Pacific Coast, as well as yellow pine from the South, are imported into this State, although her own native woods are better for general purposes and could be grown here just as well.

Among the twenty States now engaged in the wood pulp industry New York ranks first, consuming annually over 1,000,000 cords of wood for this purpose. To supply this, over 40,000 acres of virgin spruce are cut every year. The market for spruce pulp wood is literally voracious, and, according to past and present indications, will always be so. During the past two decades there has been a remarkable decrease in the manufacture of spruce lumber, and a great increase in the amount of spruce consumed for paper. In 1890 only one-fifth of the spruce cut went into pulp; in 1913 only about one-eighth went into lumber.

Small hardwoods operators in the Adirondacks complain at present of the lack of good markets. However, transportation facilities are often poor in the localities of such mills, and, until they are improved, this lack of good markets is likely to be felt, though to a diminishing degree as time goes on. As the supply of timber decreases, accessibility to city markets is bound to improve, through the agency of interested parties.

Because New York leads as a consumer of wood in its various wood-working industries, nowhere will the question of a future wood supply be felt more keenly than in this State. The question of wood substitutes often comes to the front with much prominence. It is often said that when the wood supply is gone, other materials will be found to take its place. Rising stumpage values will undoubtedly call in wood substitutes, some of which will stay. It is conceded that for certain purposes, such as house and car construction, wood substitutes may and should be used. In the last twenty years there has been developing a wider use of iron, steel, and concrete; yet carefully compiled statistics show not only a greater total consumption of wood, but also, what is most striking, an increased consumption of wood per capita. A careful analysis of the situation shows a reduction in use in one line and an increase in use in some other. Also the rapidly increasing population means a greater total consumption of wood.

The ultimate tendency is bound to be toward wood substitutes, but the change will be gradual and will not, in all probability, be such as will so far reduce the demand for wood products as to leave wood in any less favorable situation than it occupies to-day. Attempts to replace wood in important lines of utilization have not been a success. The cost of railroad ties has doubled during the past decade, but wood still remains the only source of supply, though many substitutes have been tried. The same holds true in the case of spruce for wood pulp.

Wood substitutes will never do away with the demand and use for wood, nor cause the average of wood products and timber stumpage to be lowered to any appreciable extent. Prices are still far below the level of those in Europe, and it is reasonable to expect that for some time to come these prices will continue to increase slightly faster than those for other classes of goods.

Wood preservation will undoubtedly tend to decrease the demand for wood to the extent of the benefit derived from the preservatives. But such processes will also tend to reduce the call for wood substitutes.

PRICES, PRESENT AND FUTURE

One of the very important conditions confronting a timberland owner of the future is the stumpage, or mill run, value on which he can figure with

a reasonable degree of assurance. This cannot be settled absolutely. It is generally recognized, however, that stumpage values never go down, whereas lumber prices frequently do. At the present time stumpage values range within wide limits, depending naturally on all factors concerning the exploitation of the tract under question and the kind and quality of the wood on it.

Financial values will not be discussed at this point. These are logically associated with money yields, and in that part of the bulletin dealing with those yields (page 716) will be found a much fuller discussion than it would be expedient to give here.

PRESENT ECONOMIC CONDITIONS AND THE PRIVATE OWNER

While it is true that men engaged in other industries are confronted with the same problems of market, finance, competition, and transportation, as is the lumberman, yet in many respects the lumber business is on a less stable basis, and is capable of less refinement, than are other manufacturing industries.

J. E. Rhodes, secretary for the Weyerhauser Lumber Company, states that stumpage values have not yet risen to a high enough point to make scientific forestry practicable for the private timberland owner. He says: "When the prices of stumpage have risen to the proper basis, other conditions being favorable, scientific forestry will surely be adopted by lumbermen. Lumbermen are coming to realize that something must be done if their business is to be prolonged indefinitely. If forestry cannot be undertaken with profitable results, it cannot be considered at all by private individuals, as they cannot be expected to conduct a work of this kind at a loss to themselves, no matter how much they may be prompted by sentiment or regard for future generations. The price of lumber must reach a point where it will pay to grow trees, or forestry cannot be thought of. The time when forestry can seriously be considered as a business proposition, therefore, depends entirely on the development of economic conditions. It is to help them hasten these conditions that the lumberman will appeal to the forester. Hence, the interests of the lumberman and the forester in working to this end are mutual."

For the past ten years there has been a ceaseless propaganda for better management and wiser use of timberland, and a constant controversy as to what should be done. Most of this has come from men who could do but little more than talk, while the large timberland owners, who control the destinies of the private forests, have sat back and said nothing. Conditions have now changed, and present tendencies indicate a more helpful and logical development than have those of any other time since forest conservation became an issue. Instead of attempting to put immediately

into effect the complete policies and intensive methods of management which are scientifically and theoretically correct, things are now being done which are logical steps in the development that may ultimately lead to intensive forest management on private forest lands. Fire protection and increased care in utilization constitute these first steps which must be worked out before anything more intensive can be attempted. Scarcely any large lumber company could apply ideal forestry methods at present without becoming bankrupt. The irregular virgin forests are ill adapted to this. More normal conditions must first be obtained.

OTHER GOVERNING CONDITIONS

Two other obstacles to the practice of private forestry are of the greatest importance. These are, first, fire danger, and second, unfavorable systems of taxation of woodlands.

PROTECTION FROM FIRE

Until the fire problem is settled, no one need give much thought to other forestry problems on private lands. Fire protection is the first requisite to scientific forest management. At present, practically all protection from fire that is given is through the State Forest Service. New York to-day protects against fire some 7,270,000 acres, of which the State owns 1,825,000 acres. This system is thoroughly modern and effective, and protection is afforded by the State to property worth millions of dollars at an annual cost not exceeding one-tenth of one per cent of the total value of that property.

In order to secure maximum efficiency a number of details must be improved. More lookout stations are needed. Those standing are fairly sufficient in clear weather, but when the atmosphere is smoky and hazy there is an abundance of territory which cannot be observed from them. A number of secondary lookout towers, many more miles of carefully planned telephone lines, and trails and roads to make accessible large unbroken blocks of timber, are greatly needed.

Cooperation between lumbermen and owners of timberland has not been sufficiently developed. A fair degree of fire protection has been given by the State to privately owned tracts of timberland within the forest preserve, but it is time now for the owners of those tracts to do something for themselves. In the Adirondack region, especially, excellent opportunities are presented for the successful organization of forest fire protective associations. Large contiguous areas of forest land, under the ownership of only a few persons, make this proposition thoroughly practicable and workable. Furthermore, such organizations would greatly

aid, without interfering or conflicting with, the system of protection carried on by the State.

Although the town law gives to the supervisor the same authority in his town as the State Conservation Commission has in the fire towns, it is time for New York to consider the question of establishing a system of protection which shall be state-wide in its application. Peculiar conditions that have existed in New York State, owing to the establishment of the Forest Preserve many years ago, have led thus far to the restriction of state fire protection to certain designated regions, which comprise only about one-fourth of the total area of the State. It is right and proper that the State should devote a large part of its attention to fire protection in the localities where its own forest lands are situated, but this is no reason why the remainder of the State should receive no state aid in this important work. There are many large tracts of forest land that are not included in the fire towns, besides vast areas containing valuable woodlots interspersed among agricultural lands. The woodlands outside the fire towns need and deserve fire protection as much as do those inside the preserve. Other States east, south, and west of New York have established forest fire protective systems which are state-wide and which cover regions where the fire hazard is certainly no greater than it is in the woodlands of New York outside the fire towns. What is needed is the enactment of wise legislation, which will enable the Forest Commission to establish and control a system of fire protection throughout the State. The project is entirely feasible, and could be conducted at a nominal expense to the State.

TAXATION

When one considers that the forests of New York State are being cut about three times as fast as they are growing, and that not more than one-third of all the timber used in the State is grown in the State, it is apparent that the State must adopt some fair and reasonable policy which will permit the land owner to place the land under forest growth and derive a fair profit, and which will also insure to the State its necessary wood materials.

For some years there has been agitation as to the special assessment or exemption from taxation of forest lands. Many ideas have been advanced, and for several years attempts have been made to secure legislation. In 1912 three laws were passed, as follows: (1) section 89 of chapter 444; (2) section 16 of chapter 249; (3) section 17 of chapter 363. A summary of these laws is given in table 2.

These laws have been in effect for about three years. But thirty applications have been granted. There is so much red tape or limitation that the laws are not workable.

TABLE 2. Comparison of Forest Taxation Laws

	Conservation reforesting law (Chapter 444, Laws of 1912)	General tax law relative to reforesting (Chapter 249, Laws of 1912)	General tax law relative to woodlots (Chapter 363, Laws of 1912)
Law applies to	1. Lands unsuited for agriculture	1. Any land	1. Lands maintained as woodlots
	2. Lands to be planted or underplanted	2. Lands planted or underplanted since April 10, 1909	2. Lands with natural or planted growths
	3. Areas of 5 acres and upward	3. Not less than 1 nor more than 100 acres	3. Not exceeding 50 acres
	4. Lands reforested under an agreement with Conservation Commission	4. No previous agreement required	4. Lands placed under forest managament by agreement
	5. Lands assessed at not more than $5 an acre or lands in a tax district where similar lands are not assessed at a higher rate	5. No limit as to value of land	5. No limit as to value of land
	6. Any distance from cities or villages	6. Must be situated not less than 20 miles from a city of the first class, 10 miles from a city of the second class, 5 miles from a city of the third class, or 1 mile from an incorporated village	6. Must not be situated within 20 miles of a city of the first class, 10 miles of a city of the second class, 5 miles of a city of the third class, or 1 mile of an incorporated village
Required of applicant	1. Apply to Conservation Commission on Forestry Form 68 to have land classified	1. No application necessary	1. Apply to Conservation Commission on Forestry Form 62 to have land classified
	2. Make written agreement to reforest	2. No agreement	2. Accept plan of forest management
	3. Reforest within one year after date of agreement	3. That land be reforested since April 10, 1909	3. Planting may be necessary in some cases
	4. File proof of planting with Conservation Commission, on Forestry Form 72	4. File proof of planting with Conservation Commission, on Forestry Form 66	4. No proof required by Conservation Commission
	5. Not necessary to file proof of planting with local assessors	5. File proof of planting with local assessors, on Forestry Form 65	5. No proof required by assessors
	6. Use land for forestry purposes	6. Use land for forestry purposes	6. Use land as woodlot
Benefits derived	1. Lands classified for purposes of taxation	1. Lands not classified	1. Lands classified for purposes of taxation
	2. Property assessed for period of 35 years at a value not exceeding assessed valuation of land at time of planting	2. Total exemption of assessment for 35 years on any land planted with at least 800 trees per acre. Or if underplanted with 300 trees per acre, assessed at 50 per cent of value of land exclusive of timber	2. Assessment at value of land only exclusive of tree growth, but in no case higher than $10 per acre
	3. All tree growth exempt from assessment for 35 years	3. All tree growth exempt from assessment for 35 years or more	3. All tree growth exempt from assessment for period of agreement
	4. No reduction after 35 years	4. Forest growth exempt from assessment after 35 years if forest is not cut	4. Benefit continues as long as plan is carried out

TABLE 2 (*continued*)

	Conservation reforesting law (Chapter 444, Laws of 1912)	General tax law relative to reforesting (Chapter 249, Laws of 1912)	General tax law relative to woodlots (Chapter 363, Laws of 1912)
Management of property	1. Must be used exclusively for forestry purposes	1. Must be used exclusively for forestry purposes	1. Must be used exclusively for purposes of woodlot in accordance with plan
	2. Grazing must be prohibited	2. Grazing must be prohibited	2. Grazing must be prohibited
	3. Owner can cut timber when he desires	3. No restrictions as to manner of cutting after 35 years	3. Cutting to be done in accordance with plan
Tax at cutting time	1. No cutting tax	1. Tax of 5 per cent on estimated stumpage value of material removed	1. Tax of 5 per cent of value based on actual measurement of material removed

The strict enforcement of the first law referred to — section 89 of chapter 444 — would require the entire tract entered to be planted, regardless of necessity or adaptability, or else an expensive survey to be made in order to exclude areas unsuited for reforesting from the area classified. There should be no limit of $5 or any other value as to what land may be entered. As to whether land should or should not be entered, is a question of proper use rather than of value. This value can be determined by examination.

In regard to section 16 of chapter 249, its simplicity is its chief virtue. The owner merely does the requisite planting, and files proof of such planting together with a description of the land. The purpose of this law would be included in section 89 of chapter 444 if it were not for the $5 limitation in the latter law. The theory of the law is fundamentally wrong, in that it exempts the land from taxation for thirty-five years. Forestry is not being discriminated against by repeated taxation, and forest owners are not asking for exemption or discrimination in their favor. What is asked is only fairness, and this is provided by a tax on the land value only. The tax might be paid annually, or might be deferred by providing a cutting tax when the crop is harvested and by providing that such cutting tax would be equivalent to the sum of the annual taxes.

It is extremely doubtful whether the provision in this law regarding the limitation of distances from towns and cities, in order to prevent real estate speculation, is wise or just. This would not be necessary if only the bare land were assessed.

The third law referred to — section 17 of chapter 363 — was passed in order to encourage better management of the farm woodlot. It also has too much red tape and too many limitations to accomplish its purpose.

The Legislature of New York State has gone on record as favoring a law that would give the owners of forest land more equitable taxation. The present laws have failed, largely because of their cumbersome provisions. It is fair to assume that the Legislature would pass a workable law if one were presented. The New York laws compare very favorably with those of other States, and this State has already taken a leading position in forestry legislation. There is every reason to believe that a wise law will soon be enacted.

WHAT IS BEING DONE TO-DAY

BY THE STATE

At the present time the bulk of forestry work in New York is carried on almost entirely by the State Government. In a few cases private estates have their own foresters, but generally such work is carried on in cooperation with the State Forest Service. The work of the Conservation Commission was primarily for state lands, but private owners can derive great benefit from its efforts.

Reforestation work has steadily progressed. The State supplies at cost, to private parties, trees for planting, and each succeeding year shows an increased number of trees shipped from the state nurseries. Since 1908, when the State first began this work, 14,624,000 trees have been supplied for reforestation — an amount sufficient for approximately 14,000 acres. The sale of trees to private parties has increased each year with two exceptions — 1911, when there was a slight decrease, and 1914. The numbers of trees supplied each year are as follows:

Year	Number of trees	Year	Number of trees
1908	25,000	1912	2,970,910
1909	1,095,405	1913	3,242,200
1910	1,700,000	1914	2,609,863
1911	1,670,370		

The surveying now carried on, though primarily for locating old state lines, necessarily defines those of private interests adjoining. Fire protection is given to private forests to a much greater extent than it would be if left to the owners.

Investigative and extension work has been carried on to a large extent. The subjects of fire prevention, growth, yield, tree diseases, and so on,

are constantly being studied in order that information may be sent out to every one interested in such matters.

The position of Director of Forest Investigation was created by the Legislature of 1912, and work has been conducted under this official along the following lines: forest resources; forest maps; wood-using industries; extension, including exhibits, lectures, and demonstrations.

The rapidly increasing demand for forestry literature is being satisfied as promptly as possible. Bulletins and circulars are being prepared and sent out, and talks are constantly being given before many clubs and societies.

The success of this work has been marked. Not only are the forest preserves being protected and safeguarded, but people in general are beginning to appreciate the possibilities of scientific forestry when applied to their own lands.

BY PRIVATE OWNERS

Some examples of interest in forestry by private parties are found among some of the large corporations in New York State. In the summer of 1912 a large number of examinations were made of such privately owned forest lands and advice was given in regard to their management. The International Paper Company, with the cooperation of the State Forest Service, ran a survey of over 20,000 acres of their land in the Adirondacks, and prepared a complete map. The Union Bag and Paper Company did the same work with a smaller tract of land. The management of the forests of the Webb Estate, and Ne-ha-se-ne Park, are among the best examples in New York of scientific forestry applied to private lands.

The work done in such connections show what scientific forestry can accomplish, and may serve as an object lesson in various localities.

BY THE FEDERAL GOVERNMENT

The Federal Government is contemplating ways and means by which it can aid and stimulate private forestry enterprises. This policy of the United States Forest Service is concisely stated by W. B. Greeley,[2] and is as follows:

> Aside from federal activities under the Weeks Law within the past three years, in the purchase of national forests on eastern watersheds and the protection of additional areas from fire in cooperation with States, the problems of private forestry in the East have always been close to our interests and purposes.
>
> We regard this as a field that should continue to be dealt with largely through state and private agencies; and one of the most significant and promising things about the conservation movement in America is that state forestry and the profession of private forestry have developed to such an effective point in many of the States as to cover this field of work effectively within a space of scarcely more than half a dozen years. Nevertheless, there are, I believe, certain ways in which the federal organization can help, without duplicating the efforts of local agencies but in support of their work. And such help as we can we propose to give.

[2] Greeley, W. B. National forestry. Official Pub. Cornell Univ. Proceedings at opening of Forestry Building, New York State Coll. Agr., p. 13. 1914.

Two major problems are presented in the practical adoption of forestry by private owners. The first is the problem of the larger timber holding, where forestry must stand on its own merits as an enterprise by itself. The second is the problem of the woodlot, where forestry is aided by relationship with agriculture as the principal industry.

Plans are now being perfected by the Forest Service for a survey of the conditions existing in the principal forested regions of the Eastern States in regard to the practicability of various phases of conservative management of timberlands. Under this term I include systematized fire protection and improved utilization of the timber cut, as well as measures designed to secure future forest crops. It will be the purpose of this survey to keep the Forest Service informed of what private owners and operators are attempting in any of these directions, what appears practicable for them to do under present conditions in their industry, and in what respects, if any, the Forest Service can assist in bringing about improvements in the current practice of handling timberlands. Any part of the organization of the Forest Service that can help on a specific and practical problem — be it fire protection, better utilization of the raw product, or an investigation of the possibilities of second growth — will be brought to bear on any situation where it seems that we are in a better position than any other available agency to help. Special emphasis will be given to closer and more profitable utilization, because of its tremendous importance in making more conservative cutting of timberlands economically possible.

POSSIBILITIES OF FUTURE MANAGEMENT

SILVICULTURAL MANAGEMENT AND ITS POSSIBILITIES

With the present methods of logging, no thought is given to securing a future crop of trees. Better methods of logging are possible, however, from every point of view, and these will affect the forest chiefly through the kind and amount of reproduction and growth which follows cutting, and through the conditions under which the trees develop to marketable size. Silvicultural studies by Gifford Pinchot, A. F. Hawes, and R. C. Hawley, and other men of recognized standing, show conclusively that forests, of both coniferous and hardwood species, can be reproduced both naturally and artificially. The possibility of reproducing the forests of this State is best discussed under several broad regions — the spruce region, the northern hardwoods regions, and other regions bearing more or less mixed stands of timber.

THE SPRUCE REGION

According to Gifford Pinchot, spruce has remarkable powers of reproducing itself. Large quantities of light-winged seeds are produced every year, and, on a fair seed bed, can be counted on to germinate in large numbers. Spruce seeds germinate and grow easily on deep pine or spruce duff, and on heavy moss if there is sufficient light. In hardwood litter it is more difficult to secure reproduction. It is obvious that the best management for securing spruce reproduction must be built on some clear-cutting system. Where hardwoods exist at present, selection cuttings may from necessity be used; but in such cases it will generally be the hardwoods that will be cut under this system. It will always be

difficult to secure pure spruce timberland, since some hardwoods will always come in.

Young spruce is often found on hardwood lands beyond those on which spruce is the predominating species. These trees recover well from suppression and will form the basis for future crops. There is now enough small growth already in the forests to maintain the present proportion of spruce for at least one more generation, provided it is managed properly; but the problem of increasing its proportion is a difficult one, particularly where spruce is the only species that can be marketed. The problem here is to remove old timber of one species from a mixed forest, and yet increase the proportion of the same species in the next crop. If one could cut other species gradually, the unsound as well as the lumber species, the reproduction of spruce would be simple. Under present conditions only merchantable trees can be cut, often the spruce alone, and the results desired must be accomplished by the judicious selection of trees to be cut, leaving certain specimens to distribute seed. On swamp land, on most spruce flats, and on spruce slopes where spruce forms nearly fifty per cent of the merchantable stock, this result is entirely within reach of the forester from both the silvicultural and the economic point of view; it is possible also on a considerable proportion of hardwood lands. But where beech, birch, and maple far outnumber spruce, the openings made in the forest will very probably be seeded up to hardwood species. Under such conditions the young spruce cannot compete with young hardwoods of the same age. Hardwoods start more rapidly and soon gain the upper hand. In time spruce will gradually return, but for the first generation the hardwoods will dominate.

Where hardwoods also can be marketed and the market is continuously improving, not only will the reproduction of spruce be simplified, but on lands where hardwoods have possession the cuttings can be so directed that the undesirable species will greatly decrease in the new crop.

During the Fifth National Conservation Congress at Washington in November, 1913, the Sub-Committee on Forest Planting made the following report regarding spruce: "Natural reproduction in spruce forest is good under average conditions. . . . Forest planting in the spruce region is not at present considered practicable as a general method of reproducing forests, since natural reproduction is abundant. For the most part, therefore, natural seeding will be depended upon to secure a new crop."

It is not within the scope of this bulletin to treat of detailed silvicultural management of the different types of spruce forest regions. For such information the most complete source at present is found in *Forestry in New England*, by Hawley and Hawes.

THE NORTHERN HARDWOODS REGIONS

In the northern hardwoods regions the forests are generally all aged, and are composed mostly of beech, birch, and maple, with small amounts of scattered ash, basswood, red oak, and other miscellaneous species. In every case the species just mentioned are prolific in seeding, and under good management it will be comparatively simple to secure excellent reproduction on lands now bearing these trees. The selection system is advised as giving excellent results; the extent to which this can be practiced depends on the market. The trees to be favored are birch, maple, ash, basswood, and red oak.

Where natural reproduction is to be depended on, very little more need be said; a future crop of trees is assured, and beech, birch, and maple will be in great predominance. However, these trees grow slowly under the most favorable conditions, and if forestry is to be practiced it will be money in the pocket of the owner if he will cut clear and plant to some coniferous species. The rapidity of growth and the ready market for coniferous timber make the planting of these species particularly to be chosen over the natural reproduction of the hardwoods. White and red pine and norway spruce are the trees recommended for such plantings. Where conifers are on the land now these should be saved for seed trees, and every effort should be bent to secure the conversion of these present hardwood stands to a mixed hardwood and coniferous, or a pure coniferous, forest.

REGIONS NOT CHARACTERISTICALLY SPRUCE, NOR BEECH, BIRCH, AND MAPLE

As to the remaining types of woodland in the State, while these types are varied and complex, and while it would require a volume in itself to properly treat of their silvicultural management, they are here briefly considered together.

In these forests, hardwoods may exist with no conifers. In many places white pine appears as a predominant tree; in other places it is scattered about, and may be found in mixture with hardwoods in almost every proportion. Hemlock often appears. Chestnut and oak occur over considerable areas. Toward the Lakes some red pine is found. There are white cedar and soft maple swamps in the lower places.

Regarding the silvicultural management of the lands, one must first study the type of woodland with which he has to work, and then adapt his plan of management to it. Where hardwood products are not specifically wanted, it will practically always be better to work for a coniferous forest. This may be accomplished by the silviculture best suited to the type in question. It may be clear-cutting and planting, or a selection system favoring conifers already on the ground, or clear-cutting and leaving seed trees. A detailed discussion is impossible here. Let it be sufficient

to say that here, as in the case of the other two regions, under good management reproduction can practically be guaranteed. The detailed methods of securing it will vary with the tract and the forest already on the land.

POSSIBILITIES OF CONTINUOUS PRODUCTION OF FORESTS OF VARIOUS REGIONS

Can the forest be made to produce continuously, is a question that is logically associated with the possibility of reproducing these forests, either naturally or artificially. From the discussion just preceding, the conclusions are that not only can the forests of each region be reproduced, but with scientific management this becomes a comparatively simple matter.

It is not going too far to assert positively that under the same treatment these forests can be made to produce continuously. While no illustrations of long-time forestry are at hand in New York State, one need only to refer to the forests under management in Germany and France to see how possible this is. According to the authority of Dr. Fernow, conditions are no better for timber growing there; in the majority of cases, those of this State excel. The trees here are as amenable, if not more so, to forest management.

Naturally, a tract of considerable size would be necessary in order to supply a mill or a paper company, if a continuous yield is to be obtained. This would necessitate an area of probably not less than 5000 acres. The extent of this area will naturally depend on the amount of product desired annually or periodically.

The practice of proper forestry methods will not affect the protection or the æsthetic use of the forest — points that come close to many private owners' desires. The best examples in this State are the lumbering operations as conducted on the parks of the Webb and Whitney estates. The effects of lumbering are scarcely visible to-day; these forests have cleaner floors and are freer from débris than similar areas on State land. In fact, the lumbering operations have improved the appearance of these forests, for the dead, fallen, and diseased trees have been removed, and yet the forests produce continuously. Such conditions prevail in all forest lands under management; again the forests abroad may be cited as examples.

OBJECTS OF MANAGEMENT

In the future, forests will be managed with one of the following objects in view: supply, protection, or recreation.

The real opportunity for satisfactory management comes in the case of supply forests. Here the main object is to furnish forest products.

In the large areas of New York State and in the big operations, the objects are dependent, to a large extent, on the character of the present growth, the uses to be made of the products, and the kind of material that can be produced with the greatest profit. As a general rule, for supply forests the object is to handle the woodlands in such a way that they will produce the greatest amount of wood possible and will insure cutting an amount equal approximately to the growth, thus giving a maximum and perpetual supply.

Protection forests cannot be made to bring an income to any one, and for that reason they should not be considered for private ownership. The public derives the benefit from such forests and the forests should be owned by the public. In other words, forests for regulating stream flow and for preventing the erosion of soil from mountain- and hillsides should be owned by the State.

Recreation forests are different from protection forests. Although the public may receive no benefit from these, and although they bring no income to the owner, nevertheless the pleasures derived by the owner compensate for the loss entailed by not selling forest products. If an owner can afford such luxuries, it is his private affair and concerns no one, unless very locally, except himself.

THE SPRUCE REGION

The chief object of management in the spruce forests, in the future, will be for pulp wood. A small amount will be cut for lumber and miscellaneous woodworking; this will include a varied list of uses. As already stated, the proportion of spruce used for wood pulp is increasing annually, while the amount sawed into lumber is decreasing every year. From present tendencies and indications, fully eighty per cent of the spruce grown in the future will ultimately find its way into paper.

Huge areas in the spruce country are now managed chiefly for recreation and pleasure. If it can be shown, however, that scientific management can make those forests bring in a reasonable income, without in the least destroying their use for hunting, camping, and fishing, it is highly probable that they will be placed under such management.

THE NORTHERN HARDWOODS REGIONS

Forests of beech, birch, and maple, with their associate species, will in the future be managed for each of the three objects—protection, recreation, and supply.

Forests of these species in the Catskills are excellent illustrations of forests that must be managed for protection. The forests on the rugged

slopes of the headwaters of the Esopus Creek, which feeds the large Ashokan Reservoir, must be managed primarily with this object in view.

Recreation forests are also in evidence here, as in practically every region of this type. But neither recreation nor protection forests are managed for timber. However, taking all forests into consideration, recreation forests will be found in the minority; and if forest management can be established, by far the largest proportion of forest land will be adaptable to treatment for the production of timber and wood supplies.

Where conversion to conifers is impossible or slow, the object to be attained is the production of hardwood saw logs and the subsequent lumber from these. The uses of beech, birch, and maple timber, and of other allied species, are extremely varied and numerous, and it would be of no value to enumerate them. Their use in agricultural implements, flooring, car stock, furniture, vehicle stock, and a host of novelties, stamps them as woods of great value and gives practical assurance of their future use in the same ways.

REGIONS NOT CHARACTERISTICALLY SPRUCE, NOR BEECH, BIRCH, AND MAPLE

The forests of the remaining regions will in the future be managed for practically the same objects as are stated for the northern hardwoods. Where there is white pine, box boards are likely to be the product desired, although white pine will be grown also for larger lumber and small-dimension stock. Where large tracts are in the hands of wealthy owners, recreation forests will in some cases be the only object in view. Where water supply companies control the areas around their streams, the forests will be managed primarily for protection, and then for whatever timber can safely be cut.

For the genuine supply forest, however, the chief object of management will be to grow saw logs. Poles and ties also will be in demand. The many species of trees and the many and varied uses for the wood of each will insure to the operators a ready sale for their products.

PROBABLE YIELDS

Yield is considered primarily from the standpoint of the actual increase in supply of timber, or, in other words, of volume growth. But back of this, and more important fundamentally, are the yields both in money and in interest on the investment, which in the final analysis are the yields that tell whether or not forestry practice can make the investment worth while. It is not the purely physical extent of the business carried on, but the profits accruing from it, in which every one is interested. It is not within the scope of this bulletin to construct and present original

volume yield tables. Available and reliable data already at hand have been used. The absence of satisfactory tables has prevented the calculations of money and interest yields for several species of desirable timber trees.

The yields in volume, money, and interest are here presented for three classes of timberland — white and red pine, northern hardwoods, and southern hardwoods. It would be desirable to add a fourth group — red spruce — but lack of yield data prevents this. The most comprehensive study of red spruce to date was made by Gifford Pinchot and was published in *The Adirondack Spruce*. This contains no real yield tables. The so-called yield tables merely show, for stands of definite volumes, what yields may be expected ten, twenty, or thirty years following a selection cutting, and the interval of time required to grow sufficient timber for a cut equal to that made originally. No attempts are made to base yield on age. Practically all trees used in these tables showed long periods of suppression, and on such data no true financial yields could be figured with any degree of assurance. Until yield data can be obtained, positive assurance of results cannot be given. The almost certain probability is that, owing to the long time necessary for red spruce to attain merchantable size, investment charges will mount so rapidly that no private investor can afford to grow red spruce for financial profit.

The forests of the first group, consisting of white and red pine, are the ones that will have to be formed largely through artificial methods. Both white and red pine have disappeared to such a large extent that artificial regeneration will be necessary in the great majority of cases in which forests of these species are wanted. It is greatly to be regretted that there are insufficient data on the yields of norway spruce for such a study. This species would logically fall within this group, but due to lack of investigations on the yields of plantations no results can be worked up at this time.

As already stated, beech, birch, and maple form the principal trees of the forests in the second group, that of the northern hardwoods.

In the third group, that of the southern hardwoods, the chief species considered here is chestnut. Oak and oak-chestnut forests are common, but volume yield data are too fragmentary for the calculation of money and interest yields for these species.

GROUP I. WHITE PINE AND RED PINE

In general, returns from conifers are greater than those from broad-leaved species on the same quality of soil, and, as hardwoods usually seed in naturally and abundantly, planting and encouragement of conifers

should be carried on. White and red pine should be used where possible, since these are best for the markets.

WHITE PINE (SECOND GROWTH)

VOLUME YIELDS

More time and effort have been given to the study of growth of white pine than to that of any other native tree. Consequently a large amount of reliable data is at hand. The yields per acre in board feet for sites of first, second, and third quality are shown in tables 3, 4, and 5, respectively.[3] These tables are the results of exhaustive studies of stands of second-growth white pine in New Hampshire, conducted by C. A. Lyford and Louis Margolin, of the United States Forest Service. The original tables are given in cubic feet; in the tables as presented, the values have been changed to board feet, the conversion being accomplished by using the volume tables on page 66 of the United States bulletin, which were compiled and made by the same men for the same region and give the contents in board feet. The yields are the graphical averages of the same sample plot yields as those from which the cubic-foot values were made. While these tables have been made from pine woods in New Hampshire, they can be applied equally for use in New York, as conditions in this State are just as favorable for the growth of white pine as in New Hampshire.

TABLE 3. YIELD PER ACRE IN BOARD FEET OF SECOND-GROWTH WHITE PINE (Site Quality I)

Age (years)	Diameter breast-high of average tree (inches)	Number of trees per acre	Total yield (board feet)
10	1.7	1,728	....
20	4.0	1,322	4,500
30	6.4	879	13,900
35	7.5	710	22,500
40	8.6	583	32,800
45	9.7	485	41,800
50	10.8	408	49,100
55	11.8	354	55,000
60	12.8	311	60,200
70	14.7	249	69,900
80	16.5	207	77,850
90	18.2	177	84,800
100	19.8	154	91,200

[3] The tables are adapted from those in Bulletin 13 of the United States Department of Agriculture, *White Pine under Forest Management*, by E. H. Frothingham.

TABLE 4. YIELD PER ACRE IN BOARD FEET OF SECOND-GROWTH WHITE PINE (Site Quality II)

Age (years)	Diameter breast-high of average tree (inches)	Number of trees per acre	Total yield (board feet)
10	1.4	2,015	....
20	3.2	1,626	....
30	5.1	1,192	9,600
35	6.1	950	15,900
40	7.1	760	23,500
45	8.0	633	30,600
50	8.9	537	36,600
55	9.8	460	42,000
60	10.7	397	46,900
70	12.4	311	56,100
80	14.1	251	64,000
90	15.7	210	70,900
100	17.1	182	77,000

TABLE 5. YIELD PER ACRE IN BOARD FEET OF SECOND-GROWTH WHITE PINE (Site Quality III)

Age (years)	Diameter breast-high of average tree (inches)	Number of trees per acre	Total yield (board feet)
10	1.0	2,408	....
20	2.3	2,060	....
30	3.9	1,676	5,300
35	4.7	1,400	9,300
40	5.5	1,118	14,200
45	6.3	900	19,200
50	7.0	764	24,100
55	7.8	639	29,000
60	8.6	543	33,600
70	10.1	412	42,300
80	11.7	318	50,100
90	13.2	258	57,000
100	14.5	219	62,800

The rate at which stands increase in volume — or, in other words, the mean annual increment — can be easily obtained from the preceding tables by dividing the yield by the number of years at the desired age.

Such figures can be used in comparing the rates of growth of stands of different ages and on different site qualities. The mean annual increment for average stands of the three site qualities is shown in table 6. The figures in bold-faced type represent the points of culmination of the increment.

TABLE 6. AVERAGE ANNUAL GROWTH PER ACRE OF SECOND-GROWTH WHITE PINE BY SITE QUALITY CLASSES

Age (years)	Site Quality I (board feet)	Site Quality II (board feet)	Site Quality III (board feet)
20	225	....	....
30	463	320	177
35	643	454	266
40	820	588	355
45	929	680	427
50	982	732	482
55	1,000	764	529
60	**1,003**	782	560
70	999	**801**	604
80	973	800	626
90	942	788	**633**
100	912	770	628

In a bulletin published by the State Forester of Massachusetts, the data for which were collected and compiled by H. O. Cook,[4] are volume tables for white pine in Massachusetts. The yields are obtained by practically the same methods as were used by Mr. Margolin and Mr. Lyford in New Hampshire. The values in these tables, however, are considerably higher than those given in the preceding tables. The discrepancies, no doubt, lie in the difference of sites as judged by the investigators. On examination it will be noticed that the yields for Site Qualities II and III, in the Massachusetts bulletin, correspond very closely to those of Site Qualities I and II, respectively, in the United States bulletin. In both cases, large numbers of sample plots were studied and measured, and the data in both can be regarded as authentic. However, for New York State at present, the tables in the United States bulletin seem the more conservative and are recommended for more general use.

[4] Cook, Harold O. Handbook on forest mensuration of the white pine in Massachusetts.

The yield table in the Massachusetts bulletin is here presented as table 7:

TABLE 7. YIELD PER ACRE OF WHITE PINE

Age (years)	Yield per acre (in board feet)		
	Site Quality I	Site Quality II	Site Quality III
25	10,825	6,750	3,975
30	19,900	12,500	7,500
35	31,150	24,400	16,950
40	40,650	32,800	25,200
45	49,350	40,600	32,100
50	55,150	46,500	37,550
55	59,650	50,550	42,100
60	63,600	53,200	44,550
65	67,050	56,600	46,150

MONEY YIELDS

In the money yield tables the volumes in board feet are translated to dollars and cents through the substitution of certain values per thousand feet board measure.

Two things determine the profit or loss from investments in second-growth white pine: (1) the gross returns from the financially mature stand, regarded here as stumpage value; (2) the total cost of raising white pine stands at compound interest to the end of the rotation. If the total cost of production equals the gross returns, the investment is a success. If the gross returns exceed the cost, the excess represents either a higher rate of interest than anticipated, or a clear profit at the original interest rate. If the opposite is true, the investment is unsuccessful.

At this point the consideration of white pine plantations enters. The yield tables already given have been made from fully stocked stands in every case, and are intended to show what returns can be obtained from plantations. A properly managed plantation can always be made to yield as much as any fully stocked stand in a forest produced by natural regeneration. Furthermore, calculations based on plantations are more easily worked into accessible tables. Land values and initial costs are generally known definitely, and the interest charges can be carried to the end of the rotation accurately. In many cases with second growth of natural regeneration, these charges cannot be determined with any accuracy. While the charges will be higher for a plantation, they can be relied on. If it is found in the ensuing tables that there is a possi-

bility of obtaining six per cent or more interest on an investment in a forest plantation, the results on land where formation takes place naturally will be even more favorable. Hence the volume yields already given may be considered as showing what growth may be expected both from natural second-growth white pine under forest management, and from forest plantations.

The value per thousand board feet on the stump is the difference between the market value of the finished product, and the total cost of cutting, manufacturing, and delivery, including the operator's profit on his investment. This value has been computed by the formula

$$S = \frac{M}{1.0P} - C,$$

in which S is the stumpage value, M the market value, C the operating costs, and P the operator's per cent of profit. This formula is used to a large extent by the United States Forest Service in computing stumpage values. The factors were all studied in great detail and the results set forth fully in the bulletin entitled *White Pine under Forest Management*.[5] Great care was used in determining the effect of hauling on increasing and lowering stumpage values. In table 8 the operator's profit is assumed at ten per cent. The yields on which these values are based are given in tables 3, 4, and 5.

Referring back to table 6, which gives the annual growth per acre, one can determine what the stumpage of any particular tract should be worth at the time of the culmination of the mean annual increment. Using these stumpage values, the amount of surplus profit can be determined when the stumpage value exceeds the cost of growing, computed at any desired rate of interest. The figures in tables 9 and 10 can be used safely in estimating the returns from investments in which the costs are no higher and the expected yields no lower than those given in the preceding tables. It should be remembered, however, that they are based on the yields of fully stocked stands, and in using them it will be well to allow for understocked and unmerchantable portions of the stand by assuming the area to be smaller but fully stocked. A deduction of from ten to twenty per cent of the area, depending on the intensity of management, should be ample for this purpose.

INTEREST YIELDS

The interest on the investments, computed both at a five- and at a six-per-cent valuation of money, is given in tables 9 and 10. It will be noticed

[5] See footnote, page 718.

TABLE 8. Stumpage Values per Thousand Board Feet, and per Acre, of Second-Growth White Pine Stands of Average Yields

Age (years)	Site Quality	Stumpage value, with hauling capacity of one team							
		1,000 feet per day		2,000 feet per day		3,000 feet per day		4,000 feet per day	
		Per thousand	Per acre	Per thousand	Per acre	Per thousand	Per acre	Per thousand	Per acre
20	I	....	....	$2.32	$ 10.50	$3.15	$ 14.00	$3.57	$ 16.00
	II	....	....	....	....	....	....	....	....
	III	....	....	....	....	....	....	....	....
30	I	$2.73	$ 38.00	5.23	72.50	6.06	84.00	6.48	90.00
	II	1.18	11.50	3.68	35.50	4.51	43.50	4.93	47.50
	III	....	....	2.32	12.50	3.15	16.50	3.57	19.00
35	I	3.73	84.00	6.23	140.00	7.06	159.00	7.48	168.00
	II	2.73	43.50	5.23	83.00	6.06	96.50	6.48	103.00
	III	1.18	11.00	3.68	34.00	4.51	42.00	4.93	46.00
40	I	4.18	137.00	6.68	219.00	7.51	246.50	7.93	260.00
	II	3.73	87.50	6.23	146.50	7.06	166.00	7.48	175.50
	III	2.73	38.50	5.23	74.00	6.06	86.00	6.48	72.00
45	I	4.36	182.50	6.86	287.00	7.69	321.50	8.11	339.00
	II	4.18	128.00	6.68	204.50	7.51	230.00	7.93	242.50
	III	3.73	71.50	6.23	119.50	7.06	135.50	7.48	143.50
50	I	4.55	223.00	7.05	346.00	7.88	386.50	8.30	407.50
	II	4.36	159.50	6.86	251.00	7.69	281.50	8.11	297.00
	III	4.18	101.00	6.23	161.00	7.51	181.00	7.93	191.00
55	I	4.64	255.00	7.14	392.50	7.97	438.00	8.39	461.00
	II	4.55	191.00	7.05	296.00	7.88	331.00	8.30	348.50
	III	4.36	126.50	6.86	199.00	7.69	223.00	8.11	235.50
60	I	4.73	284.50	7.23	435.00	8.06	485.00	8.48	510.50
	II	4.64	217.50	7.14	334.50	7.97	373.50	8.39	393.50
	III	4.55	152.50	7.05	236.50	7.88	264.50	8.30	278.50
70	I	4.91	347.00	7.41	521.50	8.24	579.50	8.66	609.00
	II	4.82	270.50	7.32	410.50	8.15	457.00	8.57	480.50
	III	4.73	200.00	7.23	305.50	8.06	341.00	8.48	358.50

TABLE 9. MOST PROFITABLE AGE FOR CUTTING, PROFIT OR LOSS PER ACRE, AND INTEREST EARNED IN EXCESS OF FIVE PER CENT

Daily hauling capacity (board feet)	Cost of formation	Site Quality I: Most profitable age for cutting (years)	Site Quality I: Profit or loss	Site Quality I: Interest over 5 per cent	Site Quality II: Most profitable age for cutting (years)	Site Quality II: Profit or loss	Site Quality II: Interest over 5 per cent	Site Quality III: Most profitable age for cutting (years)	Site Quality III: Profit or loss	Site Quality III: Interest over 5 per cent
1,000	....	45	$ 96.88	1.5	45	$ 56.21	1.3	50	$ 10.75	0.2
	$ 3.00	45	69.92	1.1	45	29.25	0.7	45	— 18.20	....
	6.00	45	42.97	0.6	45	2.30	0	45	— 45.15	....
	9.00	45	16.01	0.2	40	— 25.86	....	40	— 70.87	....
	12.00	40	— 4.95	....	40	— 46.98	....	35	— 89.08	....
	15.00	40	— 26.07	....	40	— 68.10	....	35	— 105.62	....
2,000	....	50	179.32	1.5	50	120.08	1.3	50	58.14	0.9
	3.00	45	151.13	1.5	45	91.17	1.3	50	23.74	0.3
	6.00	45	124.18	1.3	45	64.22	0.8	45	— 4.11	....
	9.00	45	97.22	0.8	45	37.26	0.4	45	— 31.07	....
	12.00	45	70.27	0.6	45	10.31	0.1	45	— 58.02	....
	15.00	45	43.31	0.3	45	— 16.65	....	40	— 80.77	....
3,000	....	50	207.26	1.5	50	142.15	1.4	50	73.66	1.0
	3.00	45	178.03	1.7	45	111.68	1.5	50	39.26	0.5
	6.00	45	151.08	1.4	45	84.73	1.0	45	9.37	0.2
	9.00	45	124.12	1.1	45	57.77	0.6	45	— 17.59	....
	12.00	45	97.17	0.8	45	30.82	0.4	45	— 44.54	....
	15.00	45	70.21	0.5	45	3.86	0	40	— 70.12	....
4,000	....	50	221.36	1.6	50	153.36	1.5	50	81.59	1.1
	3.00	45	191.65	1.8	45	122.10	1.6	50	47.19	0.6
	6.00	45	164.70	1.5	45	95.15	1.1	45	16.24	0.3
	9.00	45	137.74	1.2	45	68.19	0.7	45	— 10.72	....
	12.00	45	110.79	0.9	45	41.25	0.5	45	— 37.67	....
	15.00	45	83.83	0.6	45	14.28	0.1	40	— 64.71	....

TABLE 10. MOST PROFITABLE AGE FOR CUTTING, PROFIT OR LOSS PER ACRE, AND INTEREST EARNED IN EXCESS OF SIX PER CENT

Daily hauling capacity (board feet)	Cost of formation	Site Quality I			Site Quality II			Site Quality III		
		Most profitable age for cutting (years)	Profit or loss	Interest over 6 per cent	Most profitable age for cutting (years)	Profit or loss	Interest over 6 per cent	Most profitable age for cutting (years)	Profit or loss	Interest over 6 per cent
1,000	....	45	$ 63.08	1.0	45	$ 23.53	0.4	45	—$ 23.41	....
	$ 3.00	40	27.60	0.7	40	— 13.99	....	35	— 59.43	....
	6.00	40	— 3.26	....	40	— 44.85	....	35	— 82.49	....
	9.00	40	— 34.11	....	30	— 73.93	....	35	— 105.55	....
	12.00	35	— 60.09	....	30	— 91.17	....	35	— 128.61	....
	15.00	25	— 77.82	....	30	— 108.40	....	35	— 151.66	....
2,000	....	45	142.12	1.5	45	84.28	1.2	45	17.20	0.4
	3.00	45	100.33	1.0	45	42.99	0.4	45	— 24.09	....
	6.00	40	64.90	1.1	40	5.86	0.1	30	— 55.77	....
	9.00	40	34.05	0.5	40	— 24.99	....	30	— 72.99	....
	12.00	40	3.19	0	40	— 55.85	....	30	— 90.23	....
	15.00	40	— 27.67	....	35	— 83.97	....	30	— 107.46	....
3,000	....	45	168.17	1.6	45	104.35	1.3	45	30.53	0.7
	3.00	45	126.88	1.2	45	63.11	0.7	45	— 10.76	....
	6.00	40	87.38	1.1	45	21.81	0.2	40	— 46.92	....
	9.00	40	56.53	0.8	40	— 8.21	....	30	— 68.59	....
	12.00	40	25.67	0.3	40	— 39.07	....	30	— 85.83	....
	15.00	40	— 5.19	....	40	— 69.93	....	30	— 103.06	....
4,000	....	45	181.37	1.7	45	114.62	1.4	45	37.31	0.8
	3.00	45	140.08	1.3	45	73.33	0.8	45	— 3.98	....
	6.00	45	98.78	1.2	45	32.03	0.3	30	— 41.52	....
	9.00	40	67.91	0.9	40	0.33	0	30	— 66.37	....
	12.00	40	37.05	0.5	40	— 30.53	....	30	— 83.61	....
	15.00	40	6.19	0.1	40	— 61.39	....	30	— 100.84	....

that the interest per cent is that which exceeds the value per cent of the money invested. This interest is obtained by using the formula for compound interest as explained on page 66 of Chapman's *Forest Valuation*. The formula is

$$1.0x^{n} = \frac{Vn}{Vo}$$

in which x is the rate per cent of income earned, Vn the gross income (here the values from the table of stumpage prices), and Vo the value of all costs and charges at compound interest up to the time of cutting, n; n is represented in these calculations by the most profitable rotation age. The value Vo is obtained by subtracting from the stumpage values given in table 8 the respective sums of profit. The resulting figure represents the accumulated sum of all taxes, carried forward at compound interest, the interest on the value of the land, the cost of formation carried to the end of the rotation, and protection and administration charges at five cents per acre per year. Land is given an average value of $5 per acre. Land and timber taxes are figured at the rate of 1.5 per cent of full valuation, at compound interest, by decades to the seventieth year. The method of working out the ultimate value of the taxes is fully explained in the treatment of yields of interest for red pine. The tables are worked out independently for both five-per-cent and six-per-cent investments.

On inspection and study of tables 9 and 10, it will be seen that in the majority of cases white pine can be relied on to bring more than five per cent on an investment. On the most favorable sites, six per cent and even higher rates may be expected, provided the initial cost of formation is not too high and the distance from market is not too great. In a commercial investment of this sort, each location has its own peculiar and particular problems. Close study of these tables should go far toward giving a prospective investor information as to the amounts of money and the rates of interest he can reasonably hope to obtain on money so invested.

One other important feature must be noted, and that is that these results are based on stumpage figures at the present time. If stumpage values rise, as they are almost certain to do for this species, the interest on the investment will increase considerably. This point must be well kept in mind in using these tables for future predictions.

RED PINE

VOLUME YIELDS

In contrast to the large amount of work done on white pine, but very little has been done on red pine. The latest and most reliable data are

the result of studies by T. S. Woolsey and H. H. Chapman,[6] which were published in the form of a professional paper by the United States Forest Service. Table 11 is based on the returns from eighty-five sample plots in Minnesota. These figures are for theoretically even-aged, perfect stands of first-growth timber. Yield tables of this character for plantations of red pine are as yet unavailable.

TABLE 11. YIELD PER ACRE OF FULLY STOCKED, EVEN-AGED STANDS, ACCORDING TO THE THREE QUALITY CLASSES

Age (years)	Yield per acre (in board feet)		
	Site Quality I	Site Quality II	Site Quality III
40	4,100	2,000	....
50	9,400	6,100	2,800
60	15,100	10,200	5,300
70	20,900	14,300	7,900
80	26,500	18,600	10,700
90	32,300	22,900	13,700
100	38,500	27,400	16,900
110	44,700	32,000	20,100
120	50,800	36,700	23,100

These yields are for natural norway pine sites, the quality of which is at best much below that of soils occupied by white pine and hardwoods. The maximum mean annual yields on good soils hardly exceed 400 board feet, and on Quality III sites these yields do not reach 200 feet. Since norway pine will grow on any well-drained soil, if started in full sunlight the yields from plantations on the richer soils may amount to from 500 to 800 board feet per year. Although in nature the yields given in the table are seldom found, yet on well-managed plantations these yields should be obtained without question, and in many cases considerably increased.

MONEY YIELDS

Red pine now nets from $10 to $12 per thousand board feet on the stump. What it will bring in the future — sixty years and more from the present date — it is difficult to predict. Woolsey and Chapman say it is certain that it will average $20 per thousand board feet, and this figure is used in conversion of the volumes to the money yields given in table 12.

[6] Woolsey, T. S., jr., and Chapman, H. H. Norway pine in the Lake States. U. S. Agr. Dept. Bul. 139: 1–42. 1914.

TABLE 12. YIELD PER ACRE IN MONEY OF FULLY STOCKED STANDS OF NORWAY PINE

Age (years)	Money yield per acre: Site Quality I	Site Quality II	Site Quality III
40	$ 82.00	$ 40.00	....
50	188.00	122.00	$ 56.00
60	302.00	204.00	106.00
70	418.00	286.00	158.00
80	530.00	372.00	214.00
90	646.00	458.00	274.00
100	770.00	548.00	338.00
110	894.00	640.00	402.00
120	1,016.00	734.00	462.00

TABLE 13. VALUES OF INVESTMENTS IN DETAIL, BY DECADES

Age (years)	Cost of formation	Protection and administration charges	Interest on land value	Accumulated taxes on land	Taxes on timber: Site Quality I	Taxes on timber: Site Quality II	Taxes on timber: Site Quality III
			Money valued at 6 per cent				
20	$ 28.86	$ 1.84	$ 11.04	$ 2.76	....	....	....
30	51.69	3.95	23.72	5.93	....	....	....
40	92.57	7.74	46.43	11.61	....	....	....
50	165.78	14.52	87.10	21.78	$ 16.21	$ 7.90	....
60	296.90	26.66	159.94	40.00	65.94	38.33	$ 11.07
70	531.70	48.40	290.39	72.00	177.75	108.99	40.87
80	952.19	87.33	523.00	131.00	402.15	251.28	104.36
90	1,705.20	157.05	942.35	295.58	821.18	523.10	229.64
100	3,053.81	281.92	1,619.56	422.89	1,598.42	1,027.30	463.69
			Money valued at 5 per cent				
20	$ 23.85	$ 1.65	$ 8.27	$ 2.38	....	....	....
30	38.88	3.32	16.10	4.98	....	....	....
40	73.36	6.04	30.20	9.06	....	....	....
50	103.14	10.46	62.34	15.70	$ 15.47	$ 7.55	....
60	168.12	17.68	88.39	26.52	60.68	35.32	$ 10.56
70	273.87	29.43	147.13	42.96	155.78	96.01	37.21
80	446.04	48.56	242.80	72.84	332.56	210.31	90.58
90	726.57	79.77	398.66	119.60	640.99	412.72	187.89
100	1,183.50	150.50	672.50	195.75	1,167.53	758.74	357.75

INTEREST YIELDS

In computing interest, the following items are considered and given values: Land is held to be worth $5 per acre. The initial cost of formation is held at $9 per acre. Protection and administration charges are considered at the rate of 5 cents per acre per year. Taxes are considered on both land and timber at the rate of 1.5 per cent of the full valuation. As with the white pine, since land values are held as a constant at $5 per acre the taxes are figured as an annuity. The taxes accumulate on timber by decades until the one-hundredth year. Assessments are assumed to be made at intervals of ten years, instead of five as with the white pine, and the taxes for each ten-years period, accumulated as an annuity, are carried at compound interest to the end of the rotation. The figures in table 13 show the sums of the accumulated taxes for each ten-years period plus those for all preceding ten-years periods carried forward at compound interest to the specific year. The methods used for computing the interest rates on investments of red pine are identical with those in the case of white pine. The total costs of the entire investment are shown by decades in table 14:

TABLE 14. Total Values of Investments, from table 13

Age (years)	Total investment costs exclusive of taxes on timber	Total investment costs		
		Site Quality I	Site Quality II	Site Quality III
Money valued at 6 per cent				
50	$ 289.18	$ 305.39	$ 297.08	....
60	523.50	589.44	561.83	$ 534.57
70	942.49	1,120.24	1,051.48	983.36
80	1,693.52	2,095.67	1,944.80	1,797.88
90	3,100.18	3,921.36	3,623.28	3,329.82
100	5,378.18	6,976.60	6,405.48	5,841.87
Money valued at 5 per cent				
50	$ 191.64	$ 207.11*	$ 199.19*	....
60	300.71	361.39*	336.03	$ 311.27
70	493.39	649.17	598.40	530.60
80	810.24	1,142.80	1,020.55	900.82
90	1,324.60	1,965.59	1,737.32	1,512.49
100	2,202.25	3,369.78	2,960.99	2,560.00

* Profit made in this case.

Comparison of table 14 with table 12, giving the gross money yields, and table 13, giving the values of investments at compound interest, shows several facts.

With money valued at five per cent and over, and interest and taxes carried forward to the specific year in question, and yields based on the volume yield table presented previously, no profit can be returned to the investor. One or two factors may vary, and this would materially alter some of the results.

In the first place, a man may own his land and hold it due to other occupations of it. Water companies and coal companies serve as concrete illustrations. In such a case the values charged against the interest on land values can be omitted from these calculations and charged to some other feature of the corporation. Even in such a case, no profits are obtained where money is valued at six per cent. However, with money at five per cent, a slight profit is made in several instances, these being marked with an asterisk in table 14. The profits in money and in interest over five per cent are shown in table 15:

TABLE 15. PROFITS ON RED PINE
(Money valued at 5 per cent)

Age (years)	Total investment exclusive of charge of interest on land		Total returns		Profit or loss		Per cent interest earned in excess of 5 per cent	
	Site Quality I	Site Quality II	Site Quality I	Site Quality II	Site Quality I	Site Quality II	Site Quality I	Site Quality II
50.....	$144.77	$136.85	$188	$122	+ $43.23	— $14.85	+ 0.5	....
60.....	273.00	247.64	302	204	+ 29.00	— 43.64	+ 0.2	....
70.....	502.00	451.27	418	286	— 84.04	— 165.00	....	....

While the physical rotation of red pine is stated by Woolsey and Chapman to be close to one hundred and forty years, it is absurd to think of a financial rotation, with money valued as stated, of over sixty years.

While no attempt is being made to show that favorable returns can be expected from red pine, nevertheless it is felt that the yields in volume are not up to the amounts that can be obtained from scientifically managed plantations. This cannot be proved here, since the figures for such

yields are not available. Trees grown under natural conditions generally have a harder struggle and slower growth than those in plantations. The yields, as already stated, are based on forests in the former class. If these volume yields can be increased, greater interest yields will naturally follow.

For the cost of planting, $9 per acre was chosen as being an average figure. If this can be reduced, another source of reducing the investment and increasing the interest earned on it will be found. It is doubtful whether planting can be done at a figure much less than that chosen. The remaining cost figures used represent what are considered fair values.

In conclusion it may be said that, until yields from plantations prove the contrary, a private individual cannot hope to purchase waste land and plant red pine and make returns of six per cent, or even five per cent, under most conditions. Under the most favorable conditions, returns of five per cent are possible; but returns of over three and four per cent should not be expected by the present grower of red pine.

GROUP II. THE NORTHERN HARDWOODS

Although vast areas are covered with forests of hardwood trees, due to the fact that they are more or less associated with the more marketable spruce, but little thought and attention has been given them in the past regarding their prospects as forest trees for future management. The markets have been poor in the more accessible regions, and stumpage prices exceedingly low. Of late years, however, these have been steadily increasing, and to-day the northern hardwoods are being logged in large quantities.

But little work had been done previous to 1914 in studying the yields of second-growth beech, yellow birch, and sugar maple. In January, 1914, the Vermont Agricultural Experiment Station issued a bulletin[7] containing yield tables which are the best that have appeared up to the present time and the best available for use here. This bulletin is recommended to persons interested in the details of management of beech, yellow birch, and sugar maple.

VOLUME YIELDS

The yields per acre for hardwood trees of various ages and sizes are given in table 16:

[7] Hawes, A. F., and Chandler, B. A. The management of second growth hardwoods in Vermont. Vermont Agr. Exp. Sta. Bul. 176:31–86. 1914.

TABLE 16. YIELD PER ACRE OF MIXED SECOND-GROWTH HARDWOOD STANDS OF AVERAGE DENSITY

Age (years)	Diameter breast-high of average tree (inches)	Total number of trees	Lumber (board feet)	Additional cords
Site Quality I				
20	2.9	1,480	....	17.4
30	3.6	1,200	....	25.6
40	4.6	880	3,500	24.1
50	5.8	580	9,900	22.9
60	7.0	410	13,800	20.6
70	7.9	320	15,100	18.8
80	....	....	15,800	18.2
Site Quality II				
20	2.5	1,650	....	14.4
30	3.3	1,380	....	20.8
40	4.1	1,070	2,000	21.2
50	5.0	750	4,500	22.9
60	5.9	540	8,200	22.6
70	6.6	420	10,900	20.6
80	....	....	12,800	19.4
Site Quality III				
20	2.4	1,740	....	10.9
30	3.0	1,460	....	15.6
40	3.6	1,180	1,000	17.1
50	4.3	880	3,000	21.2
60	5.1	680	6,600	17.6
70	5.8	540	9,100	16.2
80	....	....	10,600	15.9

In table 17 are shown, for each site quality, the mean annual and the current annual increment in cords:

TABLE 17. MEAN AND CURRENT ANNUAL INCREMENT IN CORDS

Age (years)	Mean annual increment (cords)			Current annual increment (cords)		
	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III
40	0.83	0.67	0.50	0.74	0.54	0.46
50	0.79	0.65	0.48	0.64	0.54	0.40
60	0.75	0.61	0.47	0.52	0.42	0.34
70	0.70	0.57	0.44	0.38	0.36	0.30
80	0.66	0.53	0.42	0.34	0.28	0.22

The values given in cords in table 17 may be easily converted to board feet by allowing 500 board feet to equal one cord. This figure is conservative.

The greatest volume growth in a mixed hardwood forest occurs while the forest is rather young. In a country where there is a good market for small wood, as in some parts of Europe, a short rotation, based on the period of the greatest volume growth, would no doubt be the best policy. In the United States, and, more locally, in New York, such a market does not exist and will not for many years to come; hence the best financial results will be obtained by holding forest property until a portion of its volume has reached lumber sizes and consequently can command a better price.

MONEY YIELDS

Yields in money and interest are figured by exactly the same methods as for white pine and red pine, the factors and rates for figuring all details of investments being the same.

In converting the yield in volume to yield in money it becomes fairly difficult to find suitable stumpage figures. It is felt that a very conservative figure for stumpage calculations is $5 per thousand board feet, or $1.50 per cord. These values will in all probability be exceeded in the course of several decades, but, if they are, the table can yet be used as a guide in predicting the yields in money and interest.

TABLE 18. YIELD IN MONEY PER ACRE OF NORTHERN HARDWOODS

Age (years)	Money yield per acre		
	Site Quality I	Site Quality II	Site Quality III
20	$ 26.10	$21.60	$16.35
30	38.40	31.20	23.40
40	54.10	41.80	30.65
50	83.85	56.85	46.80
60	99.90	74.90	60.10
70	103.70	85.40	69.80
80	106.30	93.10	76.85

INTEREST YIELDS

A study of table 18 shows how small are the gross returns that can be expected from the northern hardwoods in comparison to those from white pine and red pine. These money yields are smaller in themselves

than some of the individual items concerned in figuring the total investment charges at the end of a rotation; hence it would be useless to figure interest for these, as was done for white pine and red pine.

Conclusions are that no private operator can afford to invest money in growing the mixed northern hardwoods, with money valued at five or six per cent. It is a recognized fact that, where planting is to be done, pines are the trees to be used. But at present there are many areas now coming up to a second growth of these hardwood species, where the land cost nothing, the seeding was done entirely by nature, and nothing is spent for protection and administration — in other words, lands well stocked with a young growth, which is held as being almost worthless. In such a case, the only expenses to be met are the accumulated taxes on land and timber, and those incurred from silvicultural proceedings. What is to be done with these lands? Would it be better to cut clear a stand of young growth and plant to pine, or hold the hardwood growth until it reaches merchantable size? The latter is undoubtedly the thing to do. With profits in pine remaining close to the five- and six-per-cent marks, an initial cost of clearing, carried at compound interest to the end of the rotation, would materially reduce the interest earned.

TABLE 19. VALUES OF INVESTMENTS BY DECADES

Age (years)	Silvicultural expenses	Accumulated taxes			
		On land	On timber		
			Site Quality I	Site Quality II	Site Quality III
Money valued at 6 per cent					
30	$ 3.95	$ 5.93	$ 5.15	$ 4.27	$ 3.23
40	7.74	11.61	16.86	13.98	10.43
50	14.52	21.78	40.83	....	....
60	26.66	40.00	89.43	....	....
Money valued at 5 per cent					
30	$ 3.32	$ 4.98	$ 4.92	$ 4.02	$ 3.01
40	6.04	9.06	15.11	12.46	9.20
50	10.46	15.70	34.55	28.07	20.61
60	17.63	26.52	71.89	66.24	42.40

TABLE 20. VALUES OF INVESTMENTS, GROSS RETURNS, PROFIT OR LOSS, AND INTEREST EARNED ON INVESTMENTS

Age (years)	Total value of investment			Gross returns			Profit or loss			Per cent interest earned		
	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III
	Money valued at 6 per cent									In excess of 6 per cent		
30..........	$ 15.03	$14.15	$13.11	$38.40	$31.20	$23.40	$23.37	$17.05	$10.29	3.2	2.7	2.0
40..........	36.21	33.33	29.78	54.10	41.80	30.65	17.89	8.47	0.87	1.0	0.5	0.1
50..........	77.13	......	......	83.85	56.85	46.80	6.72	....	....	0.2	......	....
60..........	156.09	......	......	99.90	74.90	60.10	— 56.19	....	....	......	......	....
	Money valued at 5 per cent									In excess of 5 per cent		
30..........	$ 13.22	$ 12.32	$11.31	$38.40	$31.20	$23.40	$25.18	$18.18	$12.09	3.6	3.1	2.5
40..........	30.21	27.56	24.30	54.10	41.80	30.65	23.89	14.24	6.35	1.5	1.0	0.6
50..........	60.71	54.23	46.77	83.85	56.85	46.80	23.14	2.62	0.03	0.6	0.2	0
60..........	116.09	110.44	86.60	99.90	74.90	60.10	— 16.19	— 35.54	— 26.50	......	......	....

With the conditions just mentioned, when accumulated taxes and silvicultural expenses represent practically the only investment charges, a profit can be obtained by holding these woodlands for thirty or forty years, depending on the current rates of interest. The values of the investments for timber on different site qualities at different ages are shown in table 19. The silvicultural expenses are assumed at five cents per acre per year. Where it is obvious that a loss is incurred, no calculations are continued.

The total values of the investments for timber on the various site qualities, the gross returns, the profit or loss, and the interest earned over six per cent and five per cent, respectively, are shown in table 20. It will be seen that the highest interest rates are found on a short rotation. If there is a market for such material, this is clearly the best rotation. However, although an arbitrary stumpage value of $5 per thousand board feet was assumed in these calculations, the trees at the age of thirty years are too small to be sawed into lumber, and until a better market exists for cordwood these percentages of interest cannot be obtained. If in the future a cordwood market for small material exists, as is the case in Europe, these values should be realized on investments of the amounts given. In no case is there found to be any profit after fifty years of growth.

It should be remembered, in using tables 19 and 20, that no investment on land or formation has been included.

GROUP III. THE SOUTHERN HARDWOODS

In many regions scattered about in the southern half of New York State are growths of what might be called southern hardwoods. Chestnut and oak, pure and in mixture with each other and with other species, are characteristic. Yields in lumber from stands of second-growth oak and oak-chestnut mixtures are not obtainable at present, and money and interest yields cannot be presented for these species.

Much has been done, however, for stands of chestnut with slight mixtures of oak. In a bulletin of the United States Forest Service[8] there are presented, more completely than in any other articles yet written, volume yields and stumpage prices for chestnut, and expenses incident to growing stands of chestnut sprouts. The subjects are treated in a manner very similar to that in which the yields of white pine were treated in the bulletin by the same author referred to under the discussion of white pine yields (page 718).

The question of the chestnut bark disease will not be discussed here. If it is found that the chestnut is doomed, no one will consider the species as a tree for future management. If this disease can be checked, table 21 may be used as a guide to the managing of chestnut stands for profit.

[8] Frothingham, E. H. Second-growth hardwoods in Connecticut. U. S. Forest Service. Bul. 96: 1–70. 1912.

TABLE 21. YIELD PER ACRE IN LUMBER AND ADDITIONAL CORDWOOD, AND IN POLES WITH ADDITIONAL TIES AND CORDWOOD, CHESTNUT TYPE

Age (years)	Lumber and additional cordwood						Poles with additional ties and cordwood								
	Site Quality I		Site Quality II		Site Quality III		Site Quality I			Site Quality II			Site Quality III		
	Lumber (board feet)	Additional cords	Lumber (board feet)	Additional cords	Lumber (board feet)	Additional cords	Poles	Additional ties	Additional cords	Poles	Additional ties	Additional cords	Poles	Additional ties	Additional cords
20	300	21	......	......	......	......	......	......	......	......	......	......	......	......	....
30	2,850	30	900	27	......	......	6	50	34	......	......	......	......	......	....
40	8,200	28	3,700	31	1,800	26	20	175	38	6	80	36	......	......	....
50	13,800	28	7,700	29	4,100	26	41	185	35	18	170	35	3	80	31
60	19,100	25	12,000	26	7,000	24	71	115	29	33	180	30	12	160	30
70	23,900	22	16,100	23	9,800	21	105	......	25	51	160	26	22	175	28

VOLUME YIELDS

As with other stands, the yields given in table 21 must be considered normal. They include, besides chestnut, the proportion of oak lumber, never exceeding twenty per cent, which commonly exists in stands of the chestnut type. The volume under *Additional cords* is that from trees too small to be cut into lumber, and from tops and branches of logged trees.

Yields are calculated for two sets of products. In the Forest Service bulletin mentioned, yields of four classes are given, these being cordwood, lumber, ties, and poles. In this discussion only the yields for lumber and additional cordwood, and for poles with additional ties and cordwood, are considered. Lumber with additional cordwood shows only medium returns. Yields from poles and additional ties and cordwood are greater than for any other class of products, and this class was chosen in order to show what may be realized from such stands. The figures in the table are for unmanaged, even-aged stands, and are based on the study of one hundred and eighty-seven sample plots.

MONEY YIELDS

The subject of money yields is treated here in much the same manner as for white pine. Stumpage prices were carefully figured by the formula already given and explained,

$$S = \frac{M}{1.0P} - C$$

for many different sets of conditions, as market price, hauling distances, and logging costs. The figures are given in table 22:

TABLE 22. STUMPAGE VALUE PER ACRE OF LUMBER AND ADDITIONAL CORDWOOD, AND OF POLES WITH ADDITIONAL TIES AND CORDWOOD

Age (years)	Lumber and additional cordwood			Poles with additional ties and cordwood		
	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III
30	$ 25.57	$16.10	....	$ 37.78	....	....
40	46.74	29.60	$19.39	92.53	$ 43.10	....
50	69.87	45.10	28.89	143.89	85.20	$35.58
60	90.38	61.50	39.95	203.83	120.90	67.08
70	108.82	77.10	50.13	267.70	160.20	92.81

The average stumpage value of $4.13 per thousand board feet was used in the converting of the volume yields of lumber to money yields. This figure is based on a market value of $18 per thousand and where stands necessitate a four-mile haul to market. In figuring these stumpages the operator was allowed twenty per cent on his investment. The stumpage value of cordwood comes to 46 cents per cord, and is based on a market price of $5 per cord. Ties are held at 15 cents apiece on the stump, based on a market value of 50 cents apiece. Poles have a stumpage value of $2.44 per pole, the market value being taken at $4.10. All these figures may be considered as conservative.

INTEREST YIELDS

The same general method of calculating total investment charges is used here as was followed for the northern hardwoods. The initial costs of land and formation are not considered in the investment charges. Only silvicultural expenses and taxes on land and timber are figured. The methods and the values are the same as used for the preceding groups. In table 23 are shown in detail, for both lumber and additional cordwood, and poles with additional ties and cordwood, the values of the investments by decades, carried forward at compound interest, at both six and five per cent. In tables 24 and 25 are shown by decades, for the two classes of products, respectively, at both rates of interest, the yields in both money and interest, the total value of the investments, and the profit or loss.

The returns from lumber are much below those from poles. Returns from ties would rank about intermediate between the two.

As market prices of products increase, so will stumpage prices. As a result there will be increase in every detail, and ultimately in the interest earned. While it is impossible to draw up tables for every set of conditions existing on the ground, the rates of interest in the following tables will show what can be expected from chestnut, under good management. When conditions differ, the tables will at least serve as guides for predicting the interest that may be obtained. Reference to them will show to any one interested a close approximation of what may be realized on the investment, and will provide a method by which one may work out the yields under his own particular existing conditions.

TABLE 23. VALUES OF INVESTMENTS BY DECADES

Age (years)	Lumber and additional cordwood					Poles with additional ties and cordwood				
	Silvicultural expenses	Accumulated taxes				Silvicultural expenses	Accumulated taxes			
		On land	On timber				On land	On timber		
			Site Quality I	Site Quality II	Site Quality III			Site Quality I	Site Quality II	Site Quality III
Money valued at 6 per cent										
30	$ 3.95	$ 5.93	....	....	....	$ 3.95	$ 5.93	....	....	....
40	7.74	11.61	$ 3.74	$ 3.18	....	7.74	11.61	$ 7.49	....	....
50	14.52	21.78	15.97	11.58	$ 3.84	14.52	21.78	31.82	$ 8.53	....
60	26.66	40.00	42.42	29.64	11.30	26.26	40.00	85.48	32.22	$ 6.65
70	48.39	72.60	93.65	65.12	28.09	48.39	72.60	193.09	81.38	25.25
Money valued at 5 per cent										
30	$ 3.32	$ 4.98	....	....	....	$ 3 32	$ 4.98	....	....	....
40	6.04	9.06	$ 3.56	$ 3.04	....	7.74	9.06	$ 7.15	....	....
50	10.46	15.70	14.62	10.54	$ 3.66	14.52	15.70	29.16	$ 8.15	....
60	17.68	26.52	37.03	25.68	10.15	26.26	26.52	74.69	29.38	$ 6.34
70	29.43	44.14	77.32	53.44	24.07	29.43	44.14	160.18	70.51	23.00

TABLE 24. Values of Investments, Gross Returns, Profit or Loss, and Interest Earned on Investments, for Lumber and Additional Cordwood

Age (years)	Total value of investment			Gross returns			Profit or loss			Per cent interest earned		
	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III
	Money valued at 6 per cent									In excess of 6 per cent		
30	......	......	......	$ 25.57	$16.10	......	....	....	....	......	......	....
40	$ 23.09	$ 22.53	......	46.74	29.60	$19.39	$ 23.65	$ 7.07	....	1.8	0.7	....
50	52.27	47.88	$ 40.14	69.87	45.10	28.89	17.60	— 2.78	—$11.25	0.6	......	....
60	109.08	96.30	77.96	90.38	61.50	39.95	— 18.70	— 34.80	— 38.01	......	......	....
70	214.64	186.11	149.08	108.82	77.10	50.13	— 105.82	— 109.01	— 98.95	......	......	....
	Money valued at 5 per cent									In excess of 5 per cent		
30	......	......	......	$ 25.57	$16.10	......	....	....	....	......	......	....
40	$ 18.66	$ 18.14	......	46.74	29.60	$19.39	$28.08	$10.46	....	2.3	1.2	....
50	40.78	36.70	$29.82	69.87	45.10	28.89	29.09	8.40	—$ 0.93	1.1	0.4	....
60	81.23	69.88	54.35	90.38	61.50	39.95	9.15	— 8.38	— 14.40	0.2	......	....
70	150.89	127.01	97.64	108.82	77.10	50.13	— 42.07	— 49.91	— 47.51	......	......	....

TABLE 25. VALUES OF INVESTMENTS, GROSS RETURNS, PROFIT OR LOSS, AND INTEREST EARNED ON INVESTMENTS, FOR POLES WITH ADDITIONAL TIES AND CORDWOOD

Age (years)	Total value of investment			Gross returns			Profit or loss			Per cent interest earned		
	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III	Site Quality I	Site Quality II	Site Quality III
	Money valued at 6 per cent									In excess of 6 per cent		
30	......	......	......	$ 37.78	......	......	....	....	....	......	......	....
40	$ 26.84	$ 19.35	......	92.53	$ 43.10	......	$65.69	$23.75	....	3.1	2.0	....
50	68.12	44.83	$ 36.30	143.89	85.20	$33.58	75.77	40.37	—$ 2.72	1.5	1.3	....
60	152.14	98.88	73.31	203.83	120.90	67.08	51.69	22.02	— 6.23	0.5	0.3	....
70	314.08	202.37	146.24	267.70	160.20	92.81	— 46.38	— 42.17	— 53.43	......	......	....
	Money valued at 5 per cent									In excess of 5 per cent		
30	......	......	......	$ 37.78	......	......	....	....	....	......	......	....
40	$ 23.95	$ 16.80	......	92.53	$ 43.10	......	$68.58	$26.13	....	3.4	2.4	....
50	59.38	38.37	$30.22	143.89	85.20	$33.58	84.51	46.83	$3.36	1.8	1.6	0.2
60	127.47	82.16	59.12	203.83	120.90	67.08	76.36	38.74	7.96	0.7	0.6	0.2
70	233.75	144.08	96.57	267.70	160.20	92.81	33.95	16.12	— 3.76	0.1	0.1	....

MOST FAVORABLE ROTATIONS

The financial rotation is obviously the one of greatest interest to a prospective investor in timber growing. He cares little about the maximum volume production; it is the rate of interest obtained with which he is chiefly concerned.

The rotations given are for the different groups of timberlands, and are those at which money can be returned to an investor in excess of a five- or a six-per-cent interest rate. This is brought out very clearly in the interest yield tables already given.

For practically every timber group, the range of time in which a rotation of native timber can be made to pay is very restricted. Every phase of growing timber has its own individual problems. For almost every class of timber, however, the rotation will fall somewhere between forty and sixty years. While some of the interest yield tables given show that a rotation of about thirty years is the most profitable, it is practically certain that this will not work out in actual practice. If there were a good market for small-sized material, a short rotation would undoubtedly prove best; but where only larger sizes can be sold, a longer rotation is required.

The best returns from white pine are found to be realized at forty, forty-five, and fifty years. Under this age limit the timber is too small, while above this limit investment charges in ordinary cases mount so high as to cause a lowering of the rate earned.

Fifty and sixty years show the best returns from red pine, with preference for a rotation of fifty years.

In the case of northern hardwoods the smaller rotation appears the more profitable, but, as already explained, is not yet feasible. Rotations of forty and fifty years are the most favorable.

Chestnut and oak are considered primarily in the group of southern hardwoods. When considered as lumber and additional cordwood, the best returns are found in rotations of forty and fifty years. If poles with additional ties and cordwood are the ultimate products, a longer rotation can be used. Forty years brings the highest returns, but money can be made on rotations of both fifty and sixty years.

SUMMARY

The tables in this bulletin give the results of attempts to show what yields in money and interest can be realized on investments in timber production. As with any set of tables, they cannot be followed to the letter. Conditions of market, distances of hauling, and expenses of logging, are so variable and complex that the impossibility of making an

absolute set of tables is apparent. The data on which these tables are based are conservative, and, so far as possible, typical of average conditions. Before attempting to predict probable yields with them, a thorough study should be made of the conditions existing locally and of the data used in their construction.

No yields are calculated which return an interest of less than five per cent. In case an investor has some reason for carrying on the work beyond that of financial profit, and is willing to grow timber for returns of less than this figure, by use of the tables he can form a fair idea as to what rate can be earned.

To sum up briefly, second-growth white pine is more desirable for management than any other class of timber. With a rotation of forty-five years, returns of six per cent and slightly over are entirely possible under average conditions. The initial cost of formation must be kept from exceeding $10 or $12, and must be brought lower where possible. Seldom will it be possible to grow white pine for over fifty years at the present rates of stumpage, and make over six per cent. Owing to the great demand for white pine by so many wood-using industries, no trouble will be experienced by any owner in disposing of his stumpage.

The returns from red pine are more problematical. The yields as shown bring but five per cent, and this rate only under the most favorable growing conditions. But these yields are based on stands of natural virgin stock. If plantation yields can be increased, returns of over six per cent can be assured here, as with white pine. Until such yield data from managed stands appear, the rate of interest earned from growing such stands cannot be given. If the yields are practically the same as given in the volume yield table for red pine, an investor cannot hope to obtain over three and four per cent from growing this species.

Yields from mixed stands of beech, birch, and maple are greatest with rotations of forty and fifty years. Over six per cent can be obtained. This rate, however, takes into account no initial cost of land or of formation, nor interest that would accrue on these costs. The investment charges represent merely taxes on land and timber and a small sum for silvicultural expenses. No planting is done with hardwoods in any region. If land must be purchased and an average price of $5 per acre is paid for it, a lower rate of interest will result. In a few cases a rate of five per cent may be obtained, but six per cent is almost impossible under such conditions.

Provided the chestnut bark disease does not prove fatal to the future growing of chestnut, this tree will be the most profitable of all hardwoods. The tendency of chestnut to sprout prolifically, its subsequent rapid growth, its varied uses for posts, poles, ties; and lumber, make it a particularly

desirable tree to deal with. Chestnut grown for lumber yields on an average close to six per cent on rotations of forty and fifty years. In the more favorable situations, this rate seems almost assured. The largest returns, however, are realized when the trees are grown for poles and for the additional ties and cordwood that will naturally result. Based on the market and stumpage values given, a rate of six per cent can be obtained on rotations of as high as seventy years. On rotations of forty and fifty years higher returns can be realized; in a few cases this will run up as high as eight per cent. As with the northern hardwoods, the rates earned take into account no initial costs for land or for formation of stand, nor interest that could be charged to these costs. These items, if included, would cause a considerable reduction in the rate of interest secured. A rotation of forty to fifty years will probably be the most favorable financially in every case.

It can be seen, therefore, that white pine and chestnut are capable of yielding the greatest returns as an investment, and are at present the only trees, with the possible exception of red pine, that can be safely grown for profit. With the danger of the bark disease looming so prominently, it is altogether uncertain whether or not chestnut can be used at all in the future. While returns of five and six per cent can be realized on the growing of beech, birch, and maple, the small size reached by these trees at the ages of forty and fifty years makes them also an uncertain element. When the markets demand material of from eight to twelve inches, then profit can be obtained with the use of these trees.

In the introduction are given a few reasons why private industry cannot be expected to practice forestry on the same scale as public institutions. Conclusions drawn from the results of these calculations bear out most of these.

Although in a number of instances a return of six per cent can be realized, a rate as high as can be earned in many other industries, this money cannot be obtained until from forty to fifty years after the initial investment is started. When an individual can have this rate of interest on his investment annually, it is only just to himself that he should enter a business in which these returns can be so obtained.

Forestry must be practiced on a large scale, and to do this requires the tying up of a large amount of capital at the start. As a result, an individual must be wealthy and at the same time willing to assume the necessary fire risks. For corporations that own their own land and desire the future use of the wood products for their own industries, reasons for private forest management are more logical. But private investors and industries cannot be expected to start investments for any other object than profit to themselves, either directly or indirectly. If the community is to receive

the benefits resulting from forests, it is the duty of the public to take charge of the forests from the first.

It is impossible to state broadcast whether or not private forest management is feasible. The state of affairs in each particular case will determine that. With certain groups of timberlands, rates as high as in any safe conservative investment are shown to be possible.

If any individual or corporation contemplates such a venture, the risks should first be studied thoroughly and it should be realized that no returns are possible for at least forty or fifty years. If the prospective investor can afford to proceed in the face of these conditions, then private forest management is possible and feasible; if not, it is a proposition for public enterprise, for either the community, the State, or the Nation.

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AGRICULTURAL EXPERIMENT STATION OF THE
NEW YORK STATE COLLEGE OF AGRICULTURE
BEVERLY T. GALLOWAY, Director
Department of Entomology

THE ARMY-WORM IN NEW YORK IN 1914

HARRY H. KNIGHT

PUBLISHED BY THE UNIVERSITY
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THE ARMY-WORM IN NEW YORK IN 1914

Leucania unipuncta Haworth[1]

Order, *Lepidoptera* Family, *Noctuidæ*

Harry H. Knight[2]

It is now eighteen years since Professor M. V. Slingerland's[3] bulletin on the army-worm was published by this station as the result of work following the serious outbreak in 1896. During 1914 came the next serious outbreak of the army-worm in New York State, and this occasion afforded an opportunity to gather considerable additional data concerning the life history and the methods of control.

HISTORY

The following paragraphs, taken from the bulletin by Professor Slingerland, give the historical account of the army-worm in New York State.

Apparently the first record of the occurrence of the army-worm in New York State is the following taken from the *Albany Argus* for 1817: "The black worm is destroying the vegetation in the northern towns of Rensselaer and the eastern section of Saratoga Counties. Many meadows and pastures have been rendered by their depredations as barren as a heath."

The insect does not seem to have again attracted attention in our State for forty-four years or until 1861. This is by far the most celebrated of the army-worm years, because the worms appeared in destructive numbers over an immense extent of country (twenty States were damaged to a greater or less extent), and also because this outbreak called forth several elaborate articles by the leading writers upon insects. In New York State the worms appeared in the vicinity of Buffalo, and at several other points towards the western and southern line of the State; and also in many places on Long Island.

In 1872, an army of the worms was reported from Tioga County. Again in 1875, which was a notable army-worm year throughout the country, the insect was very destructive in the same county and was reported as swarming on Long Island. Dr. Lintner states (*Country Gentleman*, 1877, p. 347) that the worms abounded in many portions of the State in 1876 and did serious damage, but the next year the moths were rarely seen. 1880 was also a notable army-worm year, especially in New York State. The worms were destructive in the southern and eastern counties of the State in August, and on Long Island the damage done in June was very great, creating much alarm. Bushels of the worms were captured in post holes dug in ditches on Long Island in 1880, but in 1881 scarcely any were seen on the Island.

In August, 1882, the insect appeared in formidable numbers near Saratoga Springs, and was also very destructive in Suffolk County. In 1885, the worms were reported as doing much damage in oats in Orange County. They next attracted attention in Orleans County in 1888, where they injured the barley crop twenty per cent. Two years later (1890) the worms are reported to have destroyed many acres of timothy in Queens County. This completes the record of appearances in destructive numbers of the army-worm in New York State previous to 1896.

[1] The writer prefers to use the familiar name *Leucania unipuncta* because of the unsettled condition in the classification of the group containing the army-worm moths.

[2] Mr. Knight is an industrial fellow carrying on his work in cooperation with the Genesee County Fruit Growers' Association under the direction of the Department of Entomology of Cornell University.

[3] Slingerland, M. V. The army-worm in New York. Cornell Univ. Agr. Exp. Sta. Bul. 133. 1897.

In speaking of the army-worm in the summer of 1896, Professor Slingerland states:

> In New York State the outbreak was the most widespread and most destructive of any before recorded. We have authentic reports of armies of the worms having worked in forty-eight of the sixty counties of the State. We heard nothing of the insect in the State until about July 1, when letters, telegrams, and even long-distance telephone messages began to pour in from all sections. A circular letter and telegram were prepared and for nearly three weeks in July we were kept busy answering the urgent requests of the hundreds of correspondents whose crops, in many cases, were disappearing, often at the rate of an acre or more per day, down the throats of the armies of hungry worms.

It is evident from the correspondence and reports received that the army-worm was fully as numerous and widespread in the State in 1914 as it was in 1896.

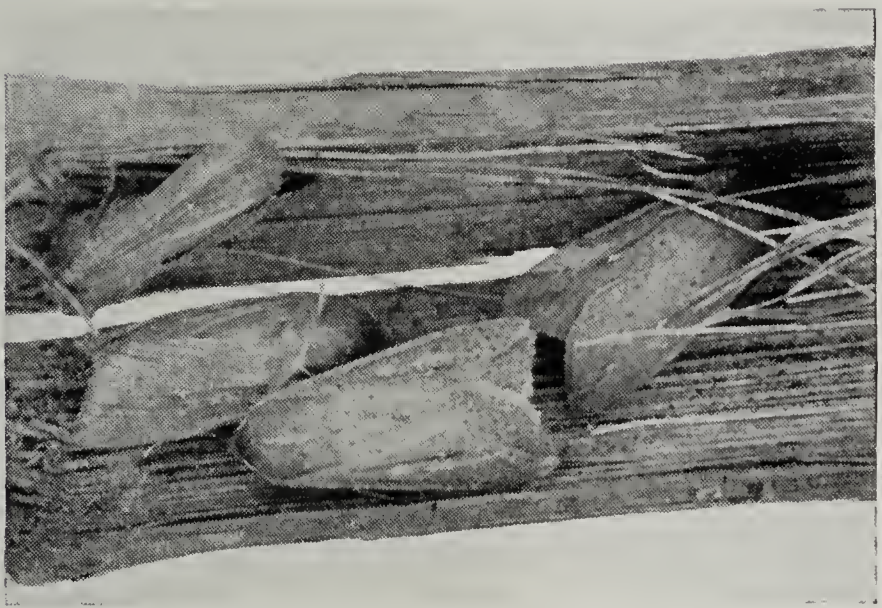
OUTBREAK IN 1914

The first indication of the presence of army-worms in 1914 in western New York was on the evening of June 12, when a moth of *Leucania unipuncta*, attracted by the light, flew into the writer's laboratory on R. E. Chapin's farm one mile south of Batavia. The next evening three moths were taken, and on the following nights more were captured. The largest number of moths came into the laboratory from June 22 to 25. The last moth observed was on June 27.

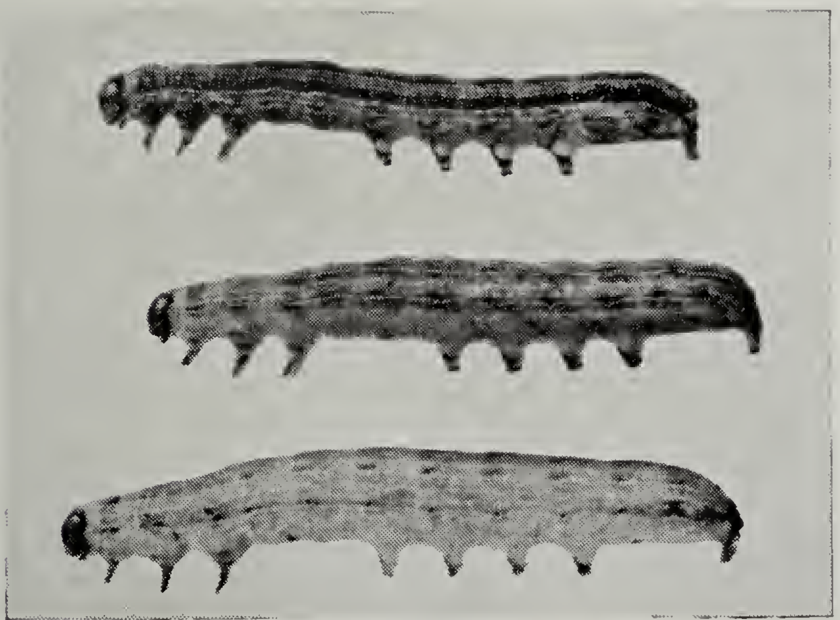
The moths were soon forgotten in the rush of work, and it was not until July 14 that attention was again called to the army-worm. On this date army-worms were noticed crossing the Alexander road near the laboratory. Examination showed that the grass bordering the road had been eaten bare in spots and that the larvæ were moving to new pastures. On the sixteenth of July the writer was called to John Price's farm, situated two and one-half miles south of Batavia, where it was found that army-worms had already consumed all the grass on about forty acres of pasture situated on low-lying ground (Plate XLIII, 2), and that the worms were rapidly approaching an adjoining cornfield. In June this was a very promising pasture with a good seeding of timothy starting new growth. It was here that certain methods of control were carried out, the details of which are given in this bulletin.

During the period from July 16 to 20, army-worms were discovered at work in several places in Genesee County and likewise in other regions of New York State. The usual type of damage was the destruction of pasture lands and the hay crop, but in many cases grain crops were seriously injured. Considerable damage was also reported from other States, namely, Indiana, Illinois, Missouri, and Kansas; reports of infestation came from Kentucky, Virginia, and all the States to the northward. Eastern Canada suffered the greatest damage by army-worms in its history.

1



2



3

1, MOTHS OF ARMY-WORM; 2, MOTHS HIDING IN CORNSTALK; 3, LARVÆ SHOWING COLOR VARIATION

1

2

1, OATS WITH HEADS AND LEAVES EATEN OFF BY ARMY-WORMS; 2, WORK OF LARVÆ ON CORN

In a bulletin by Arthur Gibson[4] the loss to crops is estimated at $300,000, the greater part of which occurred in the Province of Ontario.

FOOD PLANTS

There are certain wild grasses growing on low-lying ground that the army-worm seems to prefer above all others. The species most often eaten and the one that always showed brown first was redtop (*Agrostis alba*) and its varieties. The moths apparently laid more eggs on this grass than on all others. After the redtop was eaten bare, the larvæ moved to other plants. Bluegrass, timothy, and orchard grass were freely eaten when they came in the path of the migrating worms. Of the cultivated crops, oats suffered most with corn and barley next. The leaves of young corn plants were stripped until nothing remained but the midribs (Plate XXXVIII, 2). It was noticed that the dark-colored larvæ coming from pasture land would, after feeding two or three days on corn, become a lighter dull brown color, showing that the color of the larva is determined largely by the food plant and the amount of sunlight reaching it (Plate XXXVII, 3).

Certain leguminous plants, as has been recorded by other observers, were not touched by the army-worms. One hay field having a mixture of clover, alfalfa, timothy, and other grasses, became infested by the migrating worms with the result that all the timothy and the wild grasses were eaten close, while the clover and the alfalfa were not touched. In some places the worms entered fields of beans and peas, but no injury to these plants resulted.

WHERE THE WORMS DEVELOPED IN GENESEE COUNTY

It has been stated in the literature that army-worms usually develop in old pastures and meadows, where the rankest grass grows. During the summer of 1914 it was noted that low-lying grasslands, usually too wet for cultivation, were centers of infestation, and that from such places the worms migrated to cultivated crops. The writer also desires to stress the fact that low-lying tile-drained land sown to oats or barley, may also become heavily infested by moths, which are attracted to such situations for laying eggs.

It was clearly established that the moths may lay their eggs in a field of oats during June, and that the developing larvæ may destroy the crop. This occurred in a field of oats thirty acres in extent on the Chapin farm. The soil was largely muck, and nothing could be grown on it until it was tile-drained. In 1913 the field was planted to corn, which

[4] Gibson, Arthur. The army-worm. Canada Agr. Dept., Entomological Branch. Bul. 9. 1915.

was given the usual cultivation; in the spring of 1914 it was planted to oats. Moths were taken in close proximity to the oats during June. On July 16, the army-worm having been found on neighboring farms, a thorough search was made for it around the edges of the oat field and on adjacent grasslands, but no signs of the larvæ were found. On July 25 it was accidently discovered, while taking a short cut through the oat field, that the central and low-lying part of the field of oats was nearly destroyed by the worms. The caterpillars were working outward to higher ground as the oats were consumed, but scarcely a single larva could be found around the edges of the field, which was bordered by cultivated ground on all sides but one. Several larvæ in the third instar were found in the low ground in the central part of the field. Poisoned bait scattered through the oats was found to be a very effective control measure.

Another oat field of four acres situated on similar ground was then examined and found to be infested. At Byron, larvæ were found at work in a field of barley, which had cultivated ground on all sides. Here again the poison bait was effectively used for controlling the army-worms.

The severely infested fields of oats had the appearance of fields of smooth-stemmed reeds (Plate XXXVIII, 1), for the larvæ ate the leaves off close to the stems, then, climbing higher, devoured the heads (Plate XXXIX, 1). The pedicel was most often cut first, thus allowing the spikelets to drop before the larvæ could reach them. The ground was covered with oats cut in this way. The worms crawling over the ground were sometimes observed to eat the felled oats, but the greater part of the grain was wasted and not eaten. The scales covering the grain were eaten, but the kernel was rarely injured. From the field of thirty acres there were harvested 269 bushels of oats at a cost of $4.69 per bushel. The army-worms destroyed more than half the crop, but in addition wet weather during harvest contributed further to the loss.

THE LIFE CYCLE

JULY BROOD OF LARVÆ

On July 14 the larvæ were first found at work, and at this time many of them were more than half grown. The moths that laid the eggs for this brood were observed flying during the period from June 12 to 27. The greatest amount of damage done by the larvæ was during a period from July 14 to 25. The first pupa was found on July 21, but the majority of the larvæ pupated during the period from July 27 to August 1. The pupæ were formed in cracks in the ground, under clods (Plate XLIV, 2) and stones, or wherever the larvæ could gain access to the soil. Pupation

took place most often in the loose earth without a trace of a cocoon, but in some cases there appeared to be a slight webbing of the soil particles.

MOTHS IN AUGUST

From pupæ collected on July 26, the first moth emerged on August 8, and several more on August 10. However, it was on August 12 that the main part of the brood emerged. On that day there were showers in the morning, but the afternoon was sunshiny and very warm. In the oat field where the larvæ had been numerous, moths were observed coming out in large numbers on the higher ground which was drying off rapidly. The rain followed by the heat and the sunshine seemed to produce exactly the right condition to bring forth the moths. Hundreds were observed climbing up on oat stems or other objects to dry their wings (cover page). After the wings were fully expanded and dry, the moths usually made a short flight and sought cover under any object, such as a bit of dry cornstalk (Plate XXXVII, 2), that shielded them from the sun. When disturbed the moths flew with a rapid jerky motion, then alighted usually within twenty yards from the starting point. On August 14, when the oats were cut, the moths flew up in droves before the binder. Each evening those moths that emerged during the day flew away in all directions, probably in search of food and for mating. By August 23 it was hard to find pupæ, and the last moth observed to emerge came out on that date. It was then difficult to find a moth hiding in the field where so many had emerged previously. This may explain why the army-worm has not been recorded as injurious on the same farm two years in succession. Certain it is that the moths scattered in all directions and continued to fly during the last half of August and the first part of September. Specimens of the August brood of moths were often attracted to the electric lights in the laboratory, and on September 2 many moths were seen flying around electric lights in Batavia.

The moths fed on various sweet substances for a week or ten days before laying eggs. In the cages the moths were given sweetened water on bits of cotton and parts of ripe banana. In the open the moths were observed in the dusk of evening to feed on mashed and decaying apples, and they were also seen sipping the nectar of catnip. On September 7 one moth was observed feeding on a ripe apple hanging on the tree.

The first eggs laid in the breeding cages were deposited on August 24 by a moth that had emerged on August 12. Other moths laid on the twenty-sixth and during the week following. The eggs were laid in masses from twenty-four to sixty, tucked under the leaf sheaths at the base of oat stems (Plate XXXIX, 2), in a way very similar to that found by Professor Slingerland.

SEPTEMBER BROOD OF LARVÆ

The first egg mass hatched on September 2, and several others on the day following. The effect of larvæ on grass during the first week is shown in Plate XXXIX, 3. By September 28 most of the larvæ were one-third grown while some were nearly half grown. At this date many of them were taken from Batavia to Ithaca and placed in a large screen cage, where they were to pass the winter (Plate XL, 3). The cage was placed over a growth of orchard grass, and by October 20 most of it had been eaten by the larvæ, so that fresh grass had to be supplied. On November 4 it was noticed that several of the larvæ were full grown and remained curled at the base of the grass stools. The cage was inspected on December 2, and after short examination four pupæ were found. Larvæ were also noted, some less than half grown, others practically full grown. The remaining pupæ and larvæ were not disturbed, as it was desired to let them pass the winter in a natural condition.

PUPÆ IN NOVEMBER

Though the pupæ were not observed until December 2, it is quite evident that they were formed during the period from November 15 to 20, when the weather was unusually mild. No moths emerged before cold weather set in, and thus the brood went into winter quarters in both the larval and the pupal state.

HIBERNATION

The condition in which the insect may pass the winter has been the subject of much speculation in the past. Having this point in mind the writer was interested to learn how the pupæ and the larvæ would fare through the winter. The first spring activities were noted on March 5, when a larva was seen moving about in the cage. Before the frost had gone out of the ground, some larvæ were observed feeding on grass blades that were showing green. The cage was not disturbed at this time, but all the ground surrounding it was examined for any larvæ that might have escaped early in the fall. Five were found, which had spent the winter in stools of orchard grass. Two of these were about one-third grown, while the others were more than half grown.

The frost was well out of the ground by April 6, so an examination was made to find out how many pupæ were in the cage. The ground was dug up, and there were found fourteen pupæ and three half-transformed larvæ, which had died in that condition. Larvæ were found in all stages, from one-third grown to a few which were apparently full grown. The pupæ did not appear to be alive, and later it was found that all of them had died. When these pupæ were opened, the contents were decayed, and it was evident that they were unable to stand the winter freezing.

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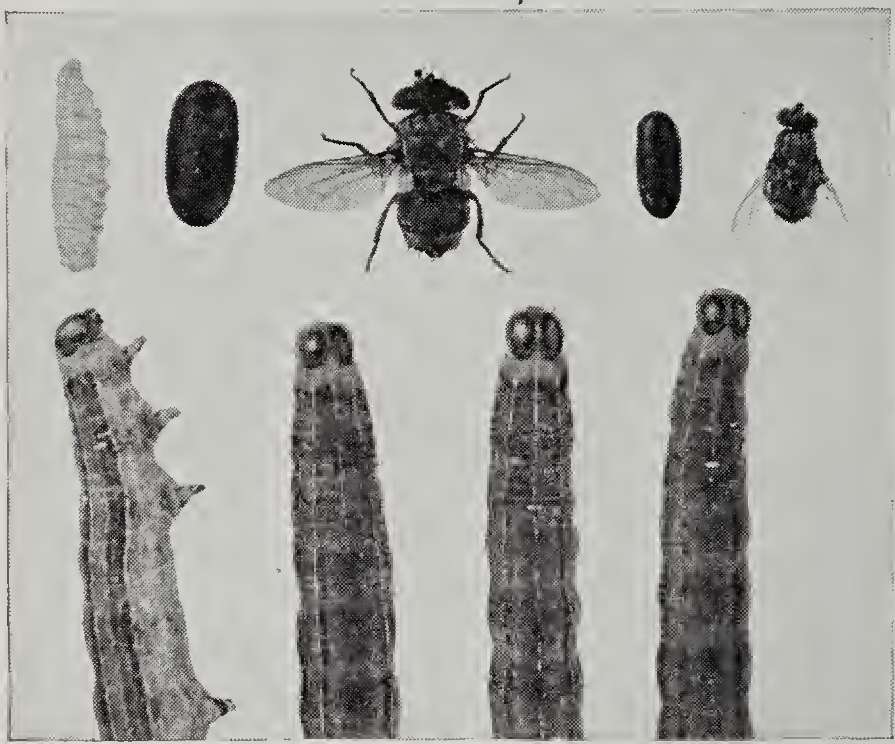
1, WORK OF ARMY-WORMS ON OAT HEADS; 2, POSITION OF EGGS ON OAT STEMS; 3, WORK OF YOUNG LARVÆ ON GRASS



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1, TWO PARASITES, *GONIOMIMA UNIFASCIATA* AND *WINTHEMIA QUADRIPUSTULATA*, OF THE ARMY-WORM WITH THEIR EGGS GLUED TO THE LARVÆ; 2, LARVÆ OF *LEUCANIA PSEUDARGYRIA*; 3, OUTDOOR CAGE IN WHICH ARMY-WORMS PASSED THE WINTER

The larvæ had pupated around the stools of grass and in among the roots, but in no case were they found at a greater depth than one inch.

On April 17, eleven of the larvæ were moved to the laboratory at Batavia. Three of the largest died of some disease the latter part of the month. It was noted that a peculiar black spot developed on the side of two larvæ, and these died very slowly. One larva had pupated by the sixteenth of May, but a predaceous beetle entered the cage and destroyed it before the moth could emerge. Another larva, which was less than half grown when the frost left the ground, had transformed and emerged as a moth on June 5. Of the larvæ that had been left over winter in a cage at Batavia, nothing but the remains of five pupæ were found. Some time was spent the latter part of April searching for the larvæ in places where the brood had been present in 1914, but none were found.

THE ARMY-WORM IN 1915

Many moths of hibernating species were captured by Dr. William T. M. Forbes and others, by means of sugar baits during the early spring at Ithaca, but no specimens of *Leucania unipuncta* were taken until May 12, when a single individual was captured. While capturing moths by this process in Cattaraugus County from June 7 to 10 from three to six moths were taken each evening. April was an unusually warm month, and had the species wintered over as moths some would have doubtless been captured during that period. There are records from New Jersey [5] of moths being taken during the winter months, but thus far there are no such records for New York.

The question is often asked why there is such an abundance of army-worms one year and none the year following. Perhaps this can never be answered accurately, but from the studies made on the 1914 broods some explanation for the scarcity of army-worms in 1915 is found.

When a brood becomes very abundant, the insect parasites and other natural enemies increase to even a greater extent. At least sixty per cent of the July brood was destroyed by these agencies. The August brood of moths was still very large, and laid eggs for the fall brood of worms. In September and October the young larvæ did not find the succulent grasses on which to feed. The natural enemies were still very abundant and took heavy toll. But the most important factor affecting army-worms appears to be weather conditions. The fall of 1914 was very mild, warm weather continuing into November. This allowed the fall brood of larvæ to become mature, and, as was noted in the cages, nearly half of them changed to the pupal state. The pupæ were unable to stand the rigors of winter, and thus half or more of the fall brood perished. The few

[5] Smith, John B. The army-worm. New Jersey Agr. Exp. Sta. Rept. Ent. Dept. 1896 : 450.

larvæ that did not attain maturity were able to hibernate in this condition. In the spring it was found that those which escaped predaceous beetles, were subject to certain diseases, and thus many of them died. Certain it is, very few moths emerged in May and June to produce a July brood of army-worms.

In 1915 moths were often taken during the last of May and the first two weeks in June but were much less abundant than during June, 1914. The summer brood of larvæ was not reared in the cages, but records of moths taken in the fall give some further data on the life history. Beginning on September 22 the writer, as well as other observers, captured specimens of the moths coming to lights. The last moth taken was on the evening of October 2. It is interesting to note that though the moths began flying at an earlier date in 1915 than the year previous, the development of the summer brood of army-worms was more prolonged, so that the moths did not come forth until the latter part of September. An explanation for this can be found in the weather conditions for the summer of 1915. The season was excessively rainy and unusually cool, which condition retards the development of the larvæ. It is evident that the fall brood of larvæ for 1915, starting so late, will not have opportunity to reach the pupal state. Thus what larvæ there are will have a better chance to pass the winter.

SUMMARY OF SEASONAL LIFE HISTORY

The army-worm first attracted attention in 1914, when an unusual number of moths began coming to the lights in the field laboratory at Batavia. The moths were observed flying about the lights from June 12 to 27. These moths laid eggs for the July brood of army-worms. The larvæ were first discovered at work in the field on July 14, at which date most of the larvæ were about half grown. From July 15 to 27 the ravages of army-worms attracted much attention throughout the State. The larvæ of this brood began pupating about July 21, but the majority transformed between July 27 and August 2. The pupal period lasted from twelve to fifteen days. Moths began emerging on August 8, but the largest number came forth on August 12. These moths began laying eggs on August 24 and continued to lay until the first part of September. By September 10 the moths had practically disappeared. The first larvæ of the second brood began hatching on September 2, and a large number of eggs hatched on the three following days. These larvæ had favorable weather for development during September and October, so that more than half the brood was mature by the middle of November. The unusually warm weather the latter part of November caused the larvæ to transform to pupæ. The cold weather of December came on before the moths had

a chance to emerge, thus the brood went into hibernation in both the pupal and the larval state. The pupæ were unable to survive the winter, consequently a large part of the brood was destroyed by natural agencies. The larvæ, which were from one-third to three-fourths grown, hibernated successfully, curling up about the roots in stools of grass. Predaceous beetles and disease killed a large part of the larvæ before they were mature in the spring, but those that survived began feeding as soon as the first grass showed green, and most of them completed their growth by the first week in May. The first moth was taken on May 12 at Ithaca. During the last week in May and for two weeks in June the moths were often taken at lights or by sugar baits. This brood of moths was not large enough to produce such armies of worms as appeared in 1914, and in fact no reports came in to indicate their presence.

The summer of 1915 was unusually damp and cool, which is an unfavorable condition for the development of the larvæ. The moths from this small summer brood did not appear until the last week in September, more than a month later than was the case in 1914. The last moth taken was on October 2, and this specimen, kept in a cage, died soon after. It is most probable that the larvæ hatching from eggs of the September moths will not be more than half grown by the time cold weather arrives. The insects will, therefore, undoubtedly pass the winter in the larval condition.

AN ALLIED SPECIES

Leucania pseudargyria Gn.

While searching for the hibernating larvæ of the army-worm during a warm spell the latter part of February, 1915, the writer found under leaves and about the roots of grasses certain reddish brown larvæ, which very much resembled those of *Leucania unipuncta*. These larvæ were later reared and found to be the closely related species, *Leucania pseudargyria*. The only noticeable difference between the larvæ of this species and those of the true army-worm was the absence of the fine yellow lines on the sides of the caterpillar. Both species hibernate as larvæ, curled up about the roots of grasses, and in this case they found good protection in stools of orchard grass. The larvæ were active and eating grass on warm days during the first week in March. Some of these were taken into the insectary and reared under artificial conditions; these developed into moths during the last of April. One larva was reared, however, under natural conditions. This individual had become full grown by May 13, and formed a slight cocoon of twisted grass roots. The larva remained in this condition of inactivity until June 2, when it changed to a pupa. The pupa was very similar to that of the army-worm, and the only difference noted was in the formation of the cocoon. In this instance the pupal period

lasted for forty-one days, as the moth did not emerge until July 12. The continual rains and cool weather through June probably prevented the moth from emerging sooner. It appears that the moth of this species, like that of the army-worm, will not emerge readily under damp, cool conditions, but after the pupa and its surroundings have had a day or two of dry weather, the moth will come forth.

NATURAL ENEMIES

When the army-worm becomes abundant, as in 1914, there appear many parasitic and predaceous enemies, which help to reduce the brood to normal numbers. Observations on the parasites that were reared from the army-worm last summer are herewith recorded, including data on certain predaceous forms.

PARASITIC ENEMIES

PARASITIC FLIES

Two species of parasitic flies were very common in the infested fields, and both are well-known enemies of the army-worm. *Winthemia quadripustulata* Fabr., known as the red-tailed tachina fly, was present in greatest numbers. This species and the yellow-tailed tachina fly, *Goniomima unifasciata* Desv., were able to parasitize from fifty to sixty per cent of the worms in certain fields. These flies glue their tiny white eggs onto the necks of the army-worms (Plate XL, 1), where the egg hatches into a maggot that bores through the skin of the larva and feeds on the tissues within. After ten or twelve days of feeding the maggot becomes mature, leaves the body of the dying caterpillar, and enters the soil. Here the maggot changes to the little brown puparium from which the fly emerges about ten days later. Often army-worms were seen that had from six to ten eggs glued to their skin. In some cases the puparia are formed in the dead body of the caterpillar, and in one instance five puparia were removed. Some maggots were able to emerge from caterpillars that were killed with poison bait. Unless the parasitic maggots were nearly mature when the host was poisoned, they were found to perish. August 12 was the first dry day following a period of damp weather, and, when the ground began to dry out, the flies and the moths came forth in hordes. The flies ran over the ground and sometimes climbed oat stems before their wings were dry. In an infested oat field the flies became so thick that their wings kept up a continual humming, somewhat similar to the buzzing of bees. The flies were rather common in the fields throughout August and well into September, when they were probably attracted to the places where the new brood was developing. As late as September

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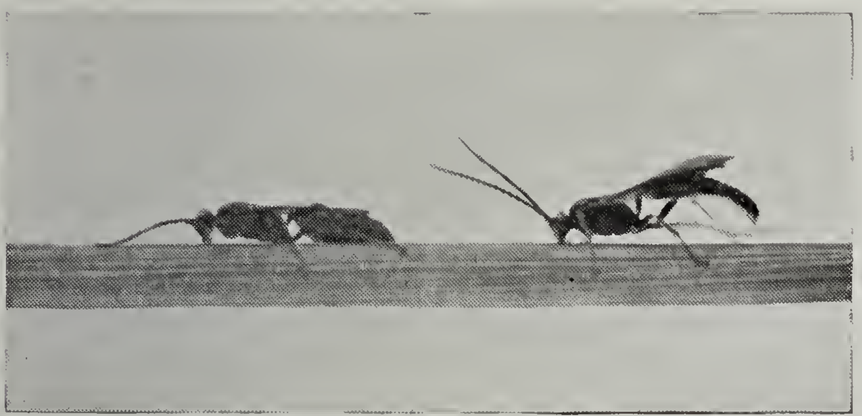

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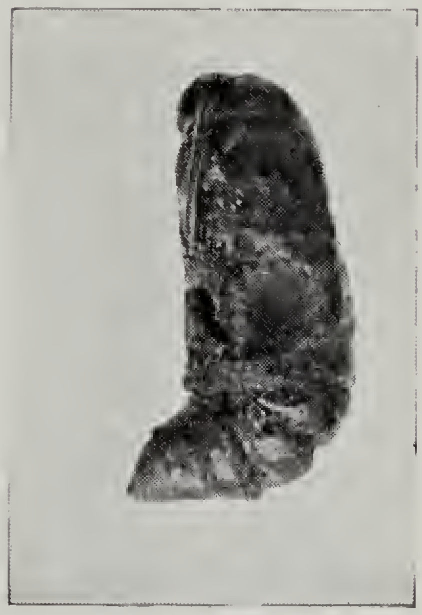

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1, *CALOSOMA CALIDUM* FEEDING ON ARMY-WORMS; 2, MALE AND FEMALE *ICHENUMON LÆTUS*; 3, COCOON OF *METEORUS COMMUNIS*; 4, MALE AND FEMALE *ICHNEUMON LÆTUS* ALIVE; 5, PUPA OF ARMY-WORM DESTROYED BY GROUND BEETLE

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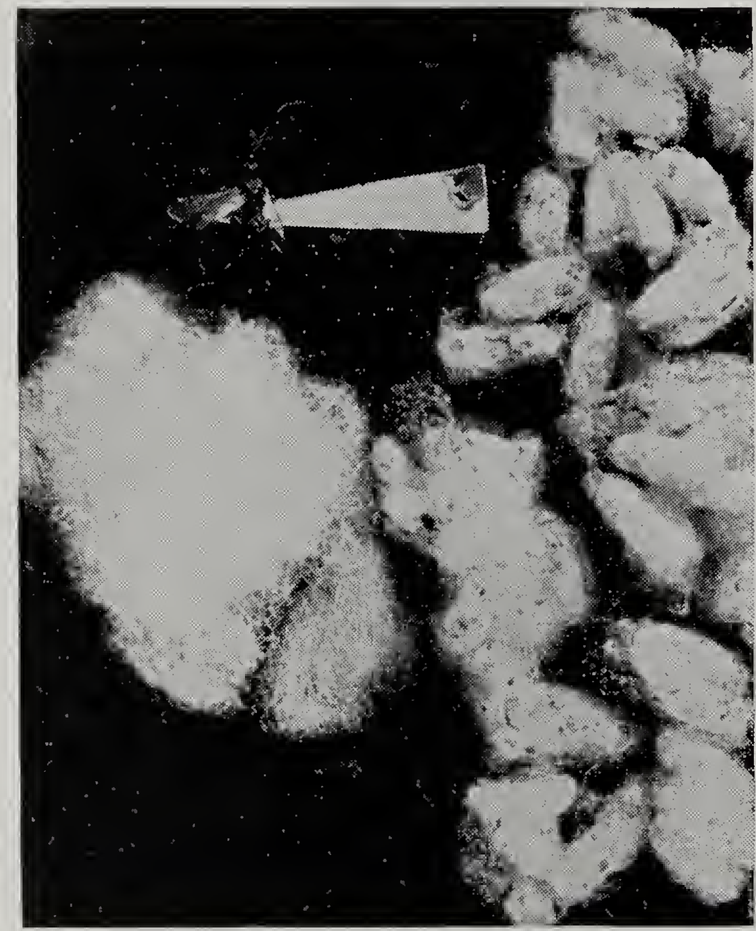

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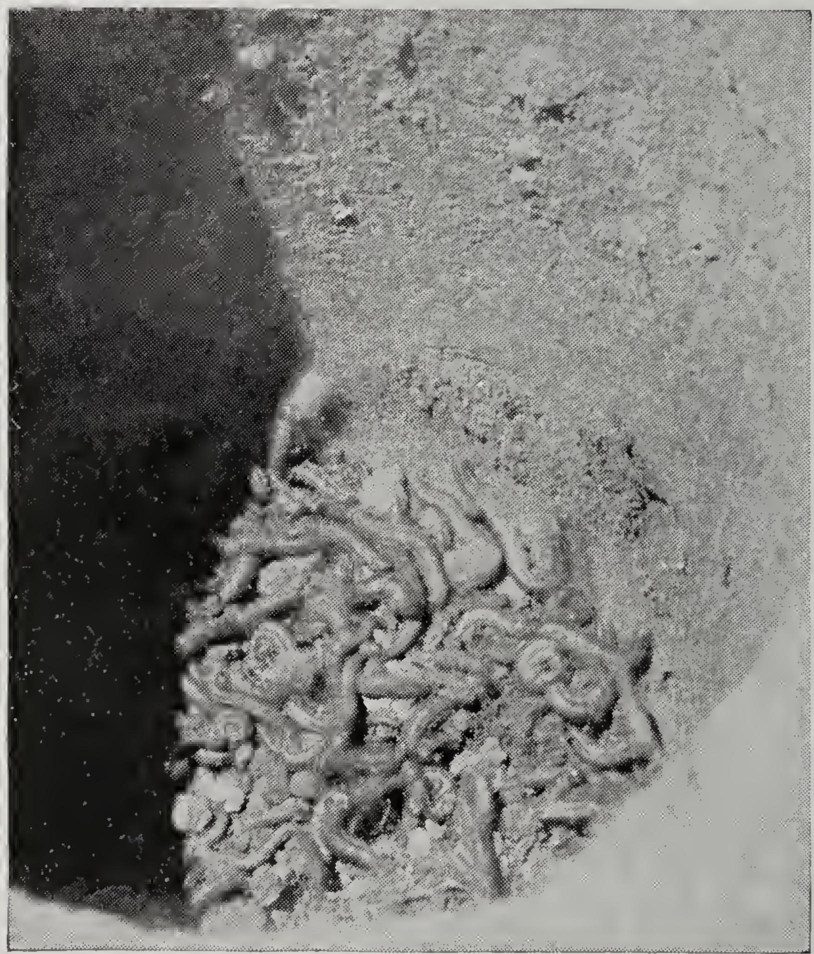

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1, A STINKBUG (*APETETICUS CYNICUS*) DESTROYING AN ARMY-WORM; 2, COCOONS OF BRACONID PARASITES; 3, ARMY-WORMS AT BOTTOM OF POST HOLE IN TRENCH

20 two or three specimens of the red-tailed tachina fly were attracted to the cages where larvæ of the new brood were kept.

BRACONID PARASITES

Meteorus communis Cresson is a very interesting little parasite, the larva of which emerges from the army-worm and spins a cocoon at the end of a silken anchor line (Plate XLI, 3). Many of these were observed attached to oat stems in badly infested fields. In an infested meadow near Corfu the cocoons of this species were very common, being attached to weeds and stems of grasses everywhere.

Apanteles militaris Walsh is a little braconid parasite which was rather common in all the infested fields. Several would emerge from one army-worm, and the groups of the tiny cotton-like cocoons were seen dotting the ground everywhere (Plate XLII, 2).

Apanteles rufocoxalis Riley was another species often bred from the army-worms, and, like the preceding species, made a group of tiny silken cocoons. These braconid parasites were kindly determined by A. B. Gahan, of the United States Bureau of Entomology.

ICHNEUMON PARASITES

Ichneumon lœtus Brullé, a large and interesting parasite, was bred in considerable numbers from the pupæ of army-worms, and certain points in the life history were determined including recognition of the female, which heretofore had gone under other names. The larva of the parasite begins to develop in the caterpillar host but does not attain its growth until the host changes to a pupa. The parasitic larva consumes the contents of the pupa, and itself nearly fills the space before pupating. From army-worm pupæ formed on July 25 to 28, male parasites began to emerge on August 15 and continued to appear during the week following. By August 22 females of *I. funestus* Cr. and *I. canadensis* Cr. began to emerge from the pupæ in cages. On August 23 the parasites were noted to be rather numerous around an oat field that was badly infested with army-worms. A male of *I. lœtus* was observed to copulate with a newly emerged female of *I. funestus* on August 25. The female was resting on an oat straw when the male approached from in front (Plate XLI, 4), grasped her quickly, at the same time thrusting its abdomen below and clasping the ovipositor with the tip of the abdomen. Copulation was observed three different times. From these observations it may be concluded that the females of *I. funestus* and *I. canadensis* are in fact the females of *I. lœtus* Brullé. This has been explained in an article in the *Journal of Economic Entomology*,[6] from which the following is quoted.

[6] Knight, H. H. Notes of *Ichneumon lœtus* Brullé. Journ. econ. ent. **8** : 514-515. 1915.

In rearing specimens it was noted that the abdomen of certain females was entirely ferruginous at emergence and then after a few hours acquired the black coloration at the base of the segments. *I. canadensis* and *I. funestus* are separated on the basis of the presence or absence of black at the base of the abdominal segments. A series of specimens shows a gradation of forms from the typical *canadensis* to *funestus*. From these observations it appears that they are females of the same species. The female of *I. lætus* and the males of *I. funestus* and *I. canadensis* have heretofore remained unrecognized. Brullé (1846) described *I. lætus* from a male. In a note following the description a female is mentioned and certain points of difference are described. Evidently this female was some other species for both Provancher and Cresson were unable to recognize the female of *I. lætus*. Say, in 1835, described the male *lætus* but instead of giving it a new name he referred to it as being the male of a previously described species, *Ichneumon paratus* Say.

It may be concluded from the foregoing breeding experiments that *I. canadensis* Cresson and *I. funestus* Cresson are females of *Ichneumon lætus* Brullé. Since *Ichneumon lætus* Brullé has priority over Cresson's species the latter must be considered synonyms.

Synonymy of *Ichneumon lætus* Brullé

1835 *Ichneumon paratus* Say (male only). Bost. Jour. Nat. Hist., **1**:228 (LeConte ed.).
1846 *Ichneumon lætus* Brullé (male only). Hist. Nat. Ins. Hym., **4** :303.
1864 *Ichneumon funestus* Cresson (female). Proc. Ent. Soc. Phil., **3** :166.
1869 *Ichneumon canadensis* Cresson (female). Trans. Am. Ent. Soc., **1** :308.
1875 *Ichneumon hoesitans* Provancher (female). Nat. Can., **7** :80.
1877 *Ichneumon hoesitans* Prov.=*funestus* Cress. Cresson, Trans. Am. Ent. Soc., **6** :179.

Males of *I. lætus* have been taken during the winter months in decaying logs. On a warm day during December, 1914, the writer took a male specimen on the walk in front of the Cornell insectary. On March 14, 1915, some twenty specimens, all females, were found hibernating in a group about eight inches from the surface in a gravel bank. This lot of specimens gives a series showing both the *canadensis* and *funestus* forms. The abundance of the species in the spring of 1915 is undoubtedly due to the unusual numbers of the army-worm in 1914.

PREDACEOUS ENEMIES

PREDACEOUS BUGS

Among the most interesting of the predaceous enemies was the large reddish brown stinkbug, *Apeteticus cynicus* Say. This species was very common, feeding on army-worms in oats. The stinkbug inserts its beak into the larva, and after a struggle the army-worm is swung free in the air, where it is unable to grasp objects. Its captor slowly sucks out the lifeblood, and after a few minutes nothing remains but the shriveled skin of the army-worm (Plate XLII, 1).

PREDACEOUS BEETLES

Of all the predaceous beetles *Calosoma calidum* Fabr., the large fiery hunter, was most conspicuous. Specimens were frequently seen in all centers of infestation, where they helped materially to reduce the numbers of army-worms. When caged, the beetles ate from three to five army-worms each day, and after a fast of two days one would eat three in

succession before stopping (Plate XLI, 1). The beetles would attack the caterpillars fiercely, sometimes biting them into halves, then consuming the blood and the fat tissues rapidly. Three beetles were attracted into the insectary by the army-worms kept in cages. In the spring of 1915 this species of predaceous beetle was observed to be much more numerous than it was the two years preceding.

Certain other species of beetles were rather common and did much to reduce the brood of army-worms. *Pterostichus lucublandus* Say was observed to feed on pupæ in the field, and when kept in cages, fed on both larvæ and pupæ. *Harpalus caliginosus* Fabr. and *Harpalus pennsylvanicus* Dej. are two species of black ground beetles that were frequently seen feeding on army-worms. They were especially effective in destroying the pupæ. *Pterostichus mutus* Say is a species that was found in the cage eating a pupa of the army-worm on December 2. These smaller beetles usually make a hole in the side of the pupæ from which they extract the contents (Plate XLI, 5).

BIRDS AND POULTRY

Certain species of birds were very numerous in fields infested with army-worms. One large hay field, situated on low ground and in the proximity of timber, was frequented daily by a large flock of crows. The crows destroyed the worms so fast that the field never became brown as was the case in all other infested meadows. Flocks of cowbirds and grackles were doing good work in some fields. The meadow lark and the robin were also observed eating the larvæ.

Poultry were very useful for destroying army-worms when an infested field came within their range. One farmer had a flock of forty turkeys, which he noticed had failed to return at feeding time. It was later found that the flock had located the army-worms in a low meadow, and finding such plentiful food they did not return to the barn for nearly two weeks. In this field the worms had eaten the ground bare only in spots, and the turkeys destroyed the pests so fast that they had no chance to migrate to adjoining grain fields.

METHODS OF CONTROL

BARRIERS

In the past the chief method of controlling army-worms has been by the use of various sorts of barriers, such as furrows, deep trenches, or dust mulches with lines of tar or similar substances. Such methods require frequent care and repairs to be effective. On certain types of ground it is quite impossible to maintain a trench that will prevent the

migrating caterpillars from crossing it. In order to prevent the larvæ from climbing up the side of the trench the ground must be in such a condition that the soil particles will crumble, loosening the hold of the caterpillar and thus allowing it to drop back to the bottom. Under the best conditions it was found difficult to entirely stop the progress of the worms by means of such a barrier. A barrier that was constructed to prevent the hordes of migrating worms from entering a cornfield is shown in Plate XLIII, 1. A trench was dug fifteen inches deep with a perpendicular side next to the corn. A plow was used to start the trench, and it was finished with spades. A post-hole digger was used to sink deep holes every few feet in the bottom of the trench, which served to trap the worms into convenient places where they could be easily destroyed (Plate XLII, 3). Such a barrier was useful for stopping the progress of the worms for a time, and when poison bait was used in connection with it, the worms usually ate some of the bait before getting across. In this way fifteen acres of corn was successfully protected from the thousands of worms that destroyed an adjoining pasture.

POISON BAIT

Knowing of the excellent results obtained with poison bait for the control of grasshoppers in Kansas, the writer decided to try a similar mixture for use against army-worms that bred in oat fields. The following formula was used:

100 pounds wheat bran
3 pounds paris green
$7\frac{1}{2}$ gallons stock molasses
7 gallons water
1 dozen oranges, chopped

The bran was dumped into a mixing box, and the paris green was added and thoroughly mixed with the dry bran. The molasses and the water were then added, and the whole was mixed thoroughly. Stock molasses, such as is fed to dairy cattle, was used. The water was necessary in order to distribute the thick molasses to every particle of bran. The oranges, finely chopped, were added, as this fruit has proved very attractive to grasshoppers. It is doubtful if the fruit is necessary for army-worms, for the molasses dominated the mixture to such an extent that one could not detect the presence of fruit juice. One man used lemons when oranges were not at hand, and the worms ate the bait equally well. In one batch of poison bait the fruit was left out entirely, and no difference in its effectiveness was noticed. When properly made, the bait should be thick and sticky in consistency.

This bait was found effective when used in connection with a barrier

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1, TRENCH BARRIER; 2, PASTURE DESTROYED BY ARMY-WORMS

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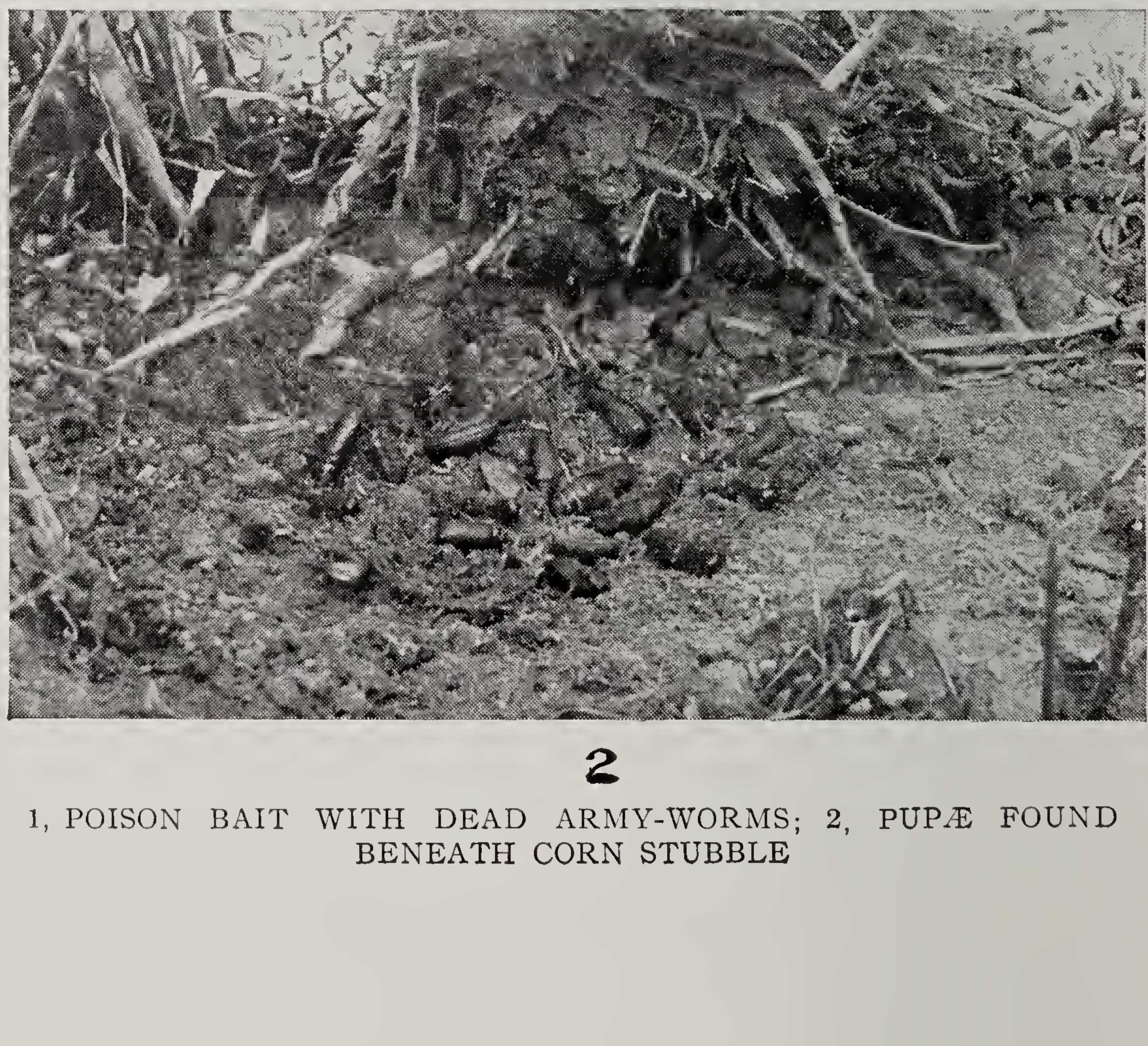

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1, POISON BAIT WITH DEAD ARMY-WORMS; 2, PUPÆ FOUND BENEATH CORN STUBBLE

to retard the onward march of the worms. The hungry larvæ usually found the bait and were poisoned before crossing the barrier.

The poison bait was used to stop the ravages of army-worms that developed in oat fields. A mixture requiring one hundred pounds of bran was used to cover fifteen acres of oats. The work was started by placing a handful of bait every twenty-five feet and covering it with a small bundle of plucked oats. It was then noticed that the hungry worms began to eat particles of bait wherever it was dropped accidently. After seeing this it was decided to scatter the bait broadcast through the oats. This was carried out by four men, each with a bucket, walking back and forth across the field and scattering the bait as evenly as possible. The next morning, July 27, the following results were noted: Dead larvæ were found covering the ground near all of the baits placed under covers. Forty-two dead larvæ were counted within three feet of one bait (Plate XLIV, 1), while 40 were counted within the same radius of the next bait. Every bait had from 30 to 50 dead larvæ within a radius of four feet. Where the bait had been scattered broadcast, the dead larvæ could be found dotting the ground everywhere. The bait remained moist and attractive to the worms for four or five days due to the thick sticky character of the molasses. By July 30 most of the army-worms were either dead or had entered the ground for pupation. Had the bait been applied sooner, it is probable that injury to the oats would have been largely avoided.

Good results were observed in killing the worms by scattering poison bait in a second oat field, while all the farmers using the bait reported good results. W. E. Herbert of Byron controlled the army-worms infesting a field of barley by scattering the poison bait broadcast.

Care should be exercised in regard to the using of poison bait. It should not be placed where fowls will find it or in pastures where stock are allowed to remain. Certain wild birds may have eaten the bait or poisoned larvæ, but this could not be ascertained.

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307 An apple orchard survey of Ontario County
313 The production of new and improved varieties of timothy
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JUNE, 1916 BULLETIN 377

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AGRICULTURAL EXPERIMENT STATION OF THE NEW YORK STATE COLLEGE OF AGRICULTURE

BEVERLY T. GALLOWAY, Director

Department of Farm Management

In cooperation with the United States Department of Agriculture, Office of Farm Management, W. J. Spillman, Chief

COST ACCOUNTS ON SOME NEW YORK FARMS

C. E. LADD

PUBLISHED BY THE UNIVERSITY
ITHACA, NEW YORK

CORNELL UNIVERSITY

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The regular bulletins of the Station are sent free on request to residents of New York State.

CONTENTS

COST ACCOUNTS ON SOME NEW YORK FARMS

C. E. Ladd [1]

INTRODUCTION

Few results of farm cost accounts have been published. The Minnesota Agricultural Experiment Station, in cooperation with the Bureau of Crop Estimates of the United States Department of Agriculture, has published results of complete sets of cost accounts for a number of farms in Minnesota,[2] while several other States have published results of limited studies of the cost of farm products.

In this bulletin results are given from complete sets of cost accounts on New York farms for the years 1912 and 1913. In 1912 accounts were closed on eighteen farms. Fourteen of these were real farms, run in a practical manner, and the results are sufficiently accurate to be used for further study. During that year much experimenting was done with various methods of accounting. In 1913 accounts were obtained from thirty-three farms.

METHODS USED IN INVESTIGATION

SYSTEM OF ACCOUNTING

The system of accounting used was essentially the same as that described in Warren's *Farm Management* and by the writer in another publication.[3] On each farm an inventory was made at the beginning and at the end of the year, care being taken to get the actual farm value of each article inventoried. In the case of animals, the value was placed at what the owner could get for them at a normal sale. Hay, grain, stalks, and other supplies were inventoried at the market price, less the cost of marketing.

Each farmer had two account books, one marked *Work Report* and the other marked *Ledger*. In the work report a record was kept of all the man hours and the horse hours worked on the farm, classified on separate pages under the name of the enterprise for which the work was done. In the ledger an account was kept of all the money paid out or received.

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[1] The writer wishes to acknowledge his appreciation of the carefulness and reliability of the farmers who cooperated in this work. Thanks are due also to Professor G. F. Warren, under whose direction the work was done, for many helpful suggestions and criticisms; to Professor K. C. Livermore, Professor A. L. Thompson, and D. S. Fox, of Cornell University, for many valuable suggestions; and to E. H. Thomson and C. M. Bennett, of the office of Farm Management, United States Department of Agriculture, for assistance and encouragement in collecting the data.

Results of accounts kept by E. B. Brunson and E. V. K. Dwinelle on six farms are included. All the accounts except on these six farms were kept in cooperation with the Office of Farm Management, United States Department of Agriculture.

[2] Cooper, T. B. The cost of Minnesota dairy products. Minnesota Agr. Exp. Sta. Bul. 124.
Hays, W. M., and Parker, E. C. Cost of producing farm products. U. S. Stat. Bur. Bul. 48.
Peck, F. W. The cost of producing Minnesota farm products, 1908–1912. Minnesota Agr. Exp. Sta. Bul. 145.

[3] Ladd, C. E. A system of farm accounting. U. S. Agr. Dept. Farmers' bul. 572:1–15. 1914.

These amounts were entered under separate accounts in the ledger as the transactions occurred. Transfers of feed or other items from one enterprise to another were made in the ledger.

At the end of the year the total number of man hours worked on the farm was found from the work report. The total cost of labor was found from the ledger. To find the labor cost per hour, the total cost was divided by the total hours worked. All labor was then charged at this rate to the various enterprises, according to the number of hours worked on each. The cost of horse labor was found and distributed in the same way. The cost of equipment use for the year was distributed among the various enterprises on the basis of the number of horse hours worked on each enterprise.

Where manure was used, ordinarily 40 per cent of the value of the manure and 40 per cent of the cost of applying it was charged to the crop receiving the application; 30 per cent of each value was charged to the next crop on the same field; 20 per cent to the third crop; and 10 per cent to the fourth. These percentages were varied somewhat according to the physical characteristics of the soil.

Further details of the system used may be found in either of the two references already cited.

METHOD OF COOPERATING

The work was undertaken, not as an extension, but as an investigative, enterprise. In most cases farmers were not asked to cooperate. After the first year so many farmers applied for the opportunity that the question became one of selecting those who seemed most likely to keep accurate records.

The College furnished all account books, and the college representative visited the farms to inspect the accounts, aided in taking inventories, and closed the accounts at the end of the year. Factors were worked on all the accounts at the end of the year, and these, together with a letter of explanation and criticism of results, were sent to the farmer. In return for these services, the College received a copy of each cooperator's books, with the understanding, however, that in using individual results the cooperator's name should not be given. The cooperators as a whole have done their part of the work faithfully, and each year a large proportion have kept on with the work for the following years.

FARMS STUDIED

TYPES OF FARMING

Several types of farming are represented in the study. In 1913, out of thirty-one farms twenty-two had herds of five or more cows. Five of

these herds consisted of purebred stock, and seventeen were grade herds or largely grades with a few purebreds. Many of these dairymen had cash crops to sell, some of these crops being potatoes, cabbage, beans, hay, wheat, buckwheat, apples, hops, tobacco, and peas. The remaining nine farmers kept only enough cows for home use, or perhaps sold a small surplus of milk or butter to neighbors. One of the nine farmers in this class fed steers, one fed sheep and steers, and one fed dry stock through the winter, in order to obtain manure and to make use of straw, bean pods, cornstalks, or poor hay. These nine farmers were selling such crops as potatoes, cabbage, beans, hay, wheat, apples, grapes, and small fruits.

Several of the farms that are located near large cities raised truck crops to a considerable extent.

AVERAGE SIZE OF FARMS COOPERATING

The average farm of New York State, according to the United States Census of 1910, comprises 102.2 acres, of which 68.8 acres are improved. The farms for which accounts were kept in 1913 average 203.6 acres and 111.5 crop acres. The fact that these farms are about twice as large as the average should be kept in mind in interpreting the results of the study.

RESULTS

MAN LABOR

The usual wages paid for farm help in 1912 and 1913 ranged from $1.25 to $2 a day for help given one or two meals; from $25 to $32 a month, with board; from $30 to $40 a month, without board. Higher wages were usually paid for short periods of time in the summer, and lower wages for the winter months. The cost of man labor on the farms studied is given in table 1:

TABLE 1. Cost of Man Labor, Including Board, House Rent, and All Other Expense

Year	Number of farms	Average cost of man labor per farm	Average number of man hours per farm	Average cost per man hour
1912	13	$1,416.33	9,009	$0.1572
1913	31	1,561.80	9,158	0.1705

Nine farms had a labor cost of more than $2,000, while eleven had a labor cost of less than $1000. One farm worked 21,743 man hours and had an average of about seven men; one farm worked 3695 man hours and had an average of about one and one-half men. Four farms had

a labor cost of less than 12 cents an hour, seven had a labor cost of more than 20 cents an hour, and twenty-three had a labor cost between 15 and 20 cents an hour.

The average distribution of labor costs is shown in table 2:

TABLE 2. AVERAGE DISTRIBUTION OF LABOR COSTS

	1912		1913	
	Average cost per farm	Per cent of total	Average cost per farm	Per cent of total
Cash paid	$517.30	36	$587.11	38
Board furnished	224.68	16	159.37	10
House rent and miscellaneous supplies	38.83	3	66.83	4
Unpaid family labor	102.98	7	174.49	11
Operator's labor	532.54	38	574.00	37
Total	$1,416.33		$1,561.80	

The amount paid in cash was about equal to the value of the operator's labor. Twenty farms used some family labor other than the operator's. Thirty-seven farms furnished board, and eleven farms furnished tenant houses, to labor.

HORSE LABOR

In finding the cost of horse labor, the cost of keeping work horses was not separated from the cost of keeping boarded horses and the cost of raising colts. All horses were reduced to a horse unit basis, two colts or one horse being counted as equal to one horse unit.

In 1912, on fourteen farms, there were 73.8 horse units, made up of 72 work horses and 3.5 colts. In 1913, on thirty-one farms, there were 189.8 horse units, made up of 173.5 work horses, 4 boarded horses, and 24.6 colts. Colts were raised in 1912 on four farms, and in 1913 on fifteen farms. The averages that concern horse labor are given in table 3:

TABLE 3. AVERAGE VALUE PER HORSE UNIT, AND OTHER FACTORS

Year	Average value per horse unit	Average size of farm (acres)	Average number of crop acres		Average number of cattle units		Average number of work horses per farm	Average number of horse units per farm
			Per farm	Per work horse	Per farm	Per work horse		
1912	$175.34	220.9	103.9	20.20	19.0	3.70	5.14	5.27
1913	156.49	203.6	111.5	19.92	21.8	3.89	5.60	6.12

The average value per horse unit on different farms varied from $74.10 to $267.56. The cheapest horses were on a small, gravelly farm, where small, light animals were used; the highest-priced horses were on a large farm with a very heavy clay soil. One farm had an average of 11.5 work horses for the year, while the smallest number was 2. The number of crop acres per work horse varied with the size of farm and the crops raised. One farm of 172 acres had 41.3 crop acres per work horse. On this farm there were 22 acres of hay, 7 acres of oats and wheat, and 12 acres of potatoes, for each work horse. One farm of 53 acres had 11 crop acres per work horse. The average figure for crop acres per work horse checks closely with the results for farms of the same size in Livingston and Jefferson Counties.[4]

The cost of keeping a horse unit for one year is apportioned as shown in table 4:

TABLE 4. Distribution of Cost of Keeping a Horse Unit for One Year (73.8 horse units in 1912, 189.8 horse units in 1913)

	1912		1913	
	Average cost per horse unit	Per cent of total cost	Average cost per horse unit	Per cent of total cost
Forage and bedding	$42.96	27	$40.90	28
Grain	57.72	36	46.39	32
Shoeing	4.24	3	4.87	3
Veterinary and medicine	2.00	1	0.69	1
Man labor	23.55	15	22.97	16
Equipment labor	0.82	1	0.67	1
Use of buildings	5.75	3	5.92	4
Interest	8.77	5	7.82	5
Miscellaneous	0.38	....	2.63	2
Depreciation	*14.03	9	†12.10	8
Total cost	$160.22		$144.96	
Manure	$12.34		$12.63	
Miscellaneous receipts	0.28		3.33	
Total manure and miscellaneous	$12.62		$15.96	
Net cost	$147.60		$129.00	

* Appreciation on four farms.
† Appreciation on eight farms.

The average cost of keeping a horse unit for one year, after deducting value of manure and miscellaneous receipts, was $147.60 in 1912 and

[4] Warren, G. F. Some important factors for success in general farming and in dairy farming. Cornell Univ. Agr. Exp. Sta. Bul. 349 : 670.

$129 in 1913. The total cost of forage, bedding, and grain per horse unit was $100.68 in 1912 and $87.29 in 1913. All grain and forage was cheaper in 1913 than in 1912. Seven farms had a forage and bedding cost per horse unit below $30, while for eight farms this cost was above $55. Of the seven farms with a low cost, five were in regions where there was a shortage in forage and bedding that year.

Four farms had a grain cost of less than $30 per horse unit, and eleven farms had a grain cost of over $60 per horse unit. None of the farms with a low forage and bedding cost had a low grain cost. On two of the farms with a low grain cost alfalfa hay was used for feed; on one the horses were worked an average of only 1.8 hours a day; and on the fourth the horses were kept in very poor condition. Four of the farms with a high grain cost had a low forage and bedding cost, and seemed to replace forage with grain.

Six farms had a man labor cost per horse unit of more than $35. None of these had winter dairies or much winter work, and so probably spent more chore time on horses than was necessary. Four of these farms kept horses in a building separate from the other stock, and labor was inefficiently used in doing chores. Eleven farms had a man labor cost per horse unit of less than $15. All of these had barns very efficiently arranged for doing chores.

The relation of the amount of business done to the cost of horse labor is shown in table 5:

TABLE 5. RELATION OF SIZE OF BUSINESS TO COST PER HOUR OF HORSE LABOR, 1913

Size of business measured in total horse hours	Number of farms	Average number of horse hours	Cost per horse hour
Less than 3,000	8	2,421	$0.1788
3,001–5,000	9	3,954	0.1730
5,001–7,000	7	6,200	0.1465
Over 7,000	7	9,442	0.1287

Records for eight farms are given in both the 1912 and 1913 tabulations. Horses on these farms were fed more when feed was cheaper. The comparative quantities of feed for the two years are shown in table 6:

TABLE 6. AVERAGE QUANTITIES OF FEED PER HORSE UNIT PER YEAR ON EIGHT FARMS IN 1912 AND ON THE SAME FARMS IN 1913

	1912	1913
Pounds of grain	3,846	4,434
Pounds of forage and bedding	7,099	7,960

EQUIPMENT

Important special machinery — such as cream separators, incubators, and gasoline engines, which are not used with horses — was inventoried under the enterprises for which it was used. All other machinery, including harnesses and small tools, was inventoried under *Equipment*. The costs for this equipment are given in table 7:

TABLE 7. Equipment Costs

Year	Number of farms	Investment in equipment per farm	Investment per crop acre	Annual cost	Per cent of average investment in annual cost	Cost per crop acre	Cost per horse hour
1912....	13	$981.46	$9.80	$249.62	25.4	$2.49	$0.0503
1913....	31	922.93	8.28	271.56	29.4	2.44	0.0513

One farm owned equipment worth $341, and one owned equipment worth $1902.50. The annual cost of equipment per crop acre was $2.49 in 1912 and $2.44 in 1913. The use of equipment was charged on the basis of the horse hours used on each enterprise. The use of equipment cost 5.03 cents per horse hour in 1912 and 5.13 cents in 1913.

The average distribution of the annual cost of equipment is shown in table 8:

TABLE 8. Average Distribution of Annual Cost of Equipment

	1912		1913	
	Average cost per farm	Per cent of total cost	Average cost per farm	Per cent of total cost
Depreciation................	$99.01	39	$124.43	45
Cash repairs................	39.66	16	38.86	14
Oil........................	1.08	1	1.53	1
Use of buildings............	29.38	12	34.86	13
Interest....................	49.07	19	46.07	17
Man labor...................	19.75	8	18.86	7
Horse labor.................	5.94	2	3.64	1
Miscellaneous...............	8.40	3	7.20	2
Total cost..............	$252.29		$275.45	
Miscellaneous receipts.......	$2.67		$3.89	
Net cost....................	$249.62		$271.56	

The average annual depreciation on equipment was 10.1 per cent of the average inventory in 1912, and 13.5 per cent of the average inventory

in 1913. The inventory value of equipment is of course much less than the cost when new.

CROPS

TIMOTHY AND CLOVER HAY

In its climate, soils, and markets, New York State is well adapted for hay production. Nearly all the farms in the State raise hay. Of the total area in crops on cooperating farms, 38 per cent in 1912, and 34 per cent in 1913, was in timothy and clover. This percentage varied from 9 to 62 on individual farms. Only one farm with which accounts have been kept did not raise timothy and clover; this farm raised alfalfa. On several farms the hay account included small fields of alfalfa or oat and pea hay. These farms were not included in the tabulation. The average yield of timothy and clover hay for New York State was 1.25 tons per acre in 1912, and 1.14 tons per acre in 1913.[5] The average yield on the cooperating farms was slightly higher than the average for the State. One farm had an average yield of 2.5 tons per acre, while on one farm the yield was only 0.66 ton per acre. Both these farms, however, made a profit in producing hay.

The data concerning the production of timothy and clover hay are given in table 9. Very little of this hay was marketed during the year.

TABLE 9. AVERAGES FOR TIMOTHY AND CLOVER HAY

	1912	1913
Number of farms	12	23
Total number of acres	487.5	823.7
Total yield in tons	679.5	1185.9
Yield per acre in tons	1.39	1.44
Value per acre	$15.53	$16.34
Cost per acre	12.58	12.31
Profit per acre	2.95	4.03
Value per ton	$11.15	$11.35
Cost per ton	9.03	8.55
Profit per ton	2.12	2.80
Profit per man hour	$0.27	$0.37
Man hours per acre	11.03	10.80
Horse hours per acre	10.50	10.25
Cost per acre aside from marketing	....	$12.11
Cost per ton aside from marketing	....	8.41
Man hours per acre aside from marketing	....	10.17
Horse hours per acre aside from marketing	....	9.74

[5] U. S. Agr. Dept. Yearbook **1913**: 418.

The value per ton used in the computation is in most cases farm value, and includes each year some hay of poor quality inventoried at $8.50 or $9 a ton.

Only five farms showed a loss on the hay account. One farm with a yield of 1.8 tons per acre made a profit of $8.75 per ton. Fourteen farms made a profit per man hour of 50 cents or more.

The number of man hours per acre varied from 5.76, on a farm that harvested 100 acres with an average yield of only 1 ton per acre, up to 21.5, on a farm with a yield of 1½ tons per acre. The latter farm was also very rough and hilly, and its hay was distributed in several small, rough, irregular fields. The number of horse hours on these two farms were 7.52 and 14.53, respectively.

In 1913, of 1185.9 tons of hay raised, 78.7 tons were marketed during the year. Some was held for sale later. The cost of production was separated from the cost of marketing. The use of buildings was charged as a cost of production. All time and charges beginning with the pressing of the hay or the removal of the hay from the mow, and including delivery to car or market, were charged to cost of marketing.

Most of the hay was sold on the understanding that the buyer should pay for the pressing. All marketing costs were figured on this basis and do not include the cost of pressing. In most cases the farmer furnished the men to pitch the hay to the press. The cost of marketing this hay is shown in table 10:

TABLE 10. COST OF MARKETING 78.74 TONS OF HAY, 1913

Man hours per ton	6.54
Horse hours per ton	5.21
Average haul in miles	3.00
Man labor cost per ton	$1.14
Horse labor cost per ton	0.72
Equipment cost per ton	0.23
Total cost per ton	$2.09

The average distribution of the cost of producing hay in 1912 and in 1913 is shown in table 11.

The hay crop has a smaller proportion of its total cost in labor than has any other crop grown on these farms. Labor (man, horse, and equipment) amounted to over thirty per cent of the total cost. Use of land, and manure and fertilizer, were the next most important costs.

TABLE 11. AVERAGES FOR HAY

	1912		1913	
	Average cost per acre	Per cent of total cost	Average cost per acre	Per cent of total cost
Seed	$0.98	8	$1.07	9
Fertilizer and manure	3.03	24	2.78	22
Man labor	1.67	13	1.80	15
Horse labor	1.70	13	1.47	12
Equipment labor	0.58	5	0.51	4
Use of land	3.61	29	3.67	30
Use of buildings	1.00	8	1.00	8
Miscellaneous	0.01	....	0.01	....
Total cost	$12.58		$12.31	

OATS

Oats are the most widely grown grain in New York State. In 1912 and 1913 all except one of the cooperating farms raised oats.

There are several reasons why many New York farmers raise oats even though the account may show a loss. On many farms oats are grown as a nurse crop with which to seed timothy and clover. Oats are also used very extensively as horse feed. The work on this crop comes at a time of the year when few other crops compete with it for labor. Oat straw is the chief bedding on many farms.

The data concerning the production of oats are given in table 12:

TABLE 12. AVERAGES FOR OATS

	1912	1913
Number of farms	10	27
Total number of acres	107.0	474.3
Total yield of grain in bushels	4,723.0	16,661.5
Yield of grain per acre in bushels	44.14	35.13
Value per acre	$20.62	$19.40
Cost per acre	23.51	22.34
Loss per acre	2.89	2.94
Value per bushel of grain *	$0.39	$0.45
Cost per bushel of grain*	0.46	0.53
Loss per bushel of grain	0.07	0.08
Loss per man hour	$.12	$.13
Man hours per acre	23.85	21.91
Horse hours per acre	33.12	30.80
Pounds of commercial fertilizer per acre	....	†201

* Without straw.
† Average for the 19 farms on which commercial fertilizer was used.

The average yield of oats in New York State was 30.8 bushels in 1912 and 33.5 bushels in 1913.[6] The average yield on the farms studied was higher in 1912 than in 1913. The farms studied in 1912 were located more generally in the grain-producing sections of the State. The average yield for 1913 is close to the average for the State for that year, and all the cost factors are probably more typical of the State as a whole than are the factors for 1912.

Eight farms raised oats at a cost of less than $20 an acre, and on one farm the cost was as low as $13.30 an acre. This farm raised oats after potatoes, without plowing the land for the oats; in this way a large part of the labor cost was saved.

Seven farms made a profit in producing oats. One farm raised 73.6 bushels per acre at a cost of $19.20. This farm made a profit of $14.09 per acre, or 58 cents per man hour, on its oats.

The average distribution of the cost of raising oats is shown in table 13:

TABLE 13. AVERAGE DISTRIBUTION OF COST OF PRODUCING OATS

	1912		1913	
	Average cost per acre	Per cent of total cost	Average cost per acre	Per cent of total cost
Seed	$2.04	9	$1.20	5
Fertilizer and manure	3.90	17	5.57	25
Man labor	3.83	16	3.60	16
Horse labor	5.72	24	4.59	21
Equipment labor	1.58	7	1.59	7
Use of land	3.70	16	3.83	17
Use of buildings	1.24	5	0.69	3
Threshing	1.12	5	0.90	4
Twine	0.30	1	0.20	1
Miscellaneous	0.08	....	0.17	1
Total cost	$23.51		$22.34	

Labor cost (man, horse, and equipment) represents from 45 to 50 per cent of the total cost of growing oats. Use of land constitutes only from 16 to 17 per cent of the total cost. The fertilizer and manure charge against oats is rather large. Most of the manure, however, is not applied directly to the oats, but is the estimated residual value from manure on the previous crop, which is generally a cultivated crop and ordinarily receives a large quantity of manure.

[6] U. S. Agr. Dept. Yearbook 1913: 391.

SILAGE CORN

Many dairy farmers in New York State have ceased to raise corn for grain, and now raise this crop for silage only. This is a relatively new enterprise for most farmers, and the yields, costs, and values for silage corn are less known than are those for the older crops.

In order to obtain the total yield of silage corn on each farm, the silos were measured and their capacity was computed on the basis of tables given in King's *Physics of Agriculture*. The value per ton was estimated as about one-third that of timothy hay. This value was varied somewhat with the quality of the silage, the amount of grain contained, and other factors.

The data concerning the production of silage corn are given in table 14:

TABLE 14. AVERAGES FOR SILAGE CORN

	1912	1913
Number of farms	7	21
Total number of acres	101.0	262.8
Total yield in tons	809.0	1,659.5
Yield per acre in tons	8.01	6.31
Value per acre	$33.00	$26.04
Cost per acre	31.27	32.59
Profit or loss per acre	1.73	– 6.55
Value per ton	$4.12	$4.12
Cost per ton	3.90	5.16
Profit or loss per ton	0.22	— 1.04
Profit or loss per man hour	$0.05	—$0.16
Man hours per acre	37.4	41.8
Horse hours per acre	52.9	59.4
Pounds of commercial fertilizer per acre	......	*325

* Average for the 14 farms that used commercial fertilizer on corn.

Weather conditions in 1912 were favorable for the production of corn, and the yield was 8.01 tons per acre. On September 8, 1913, there was a hard freeze throughout most of New York State. Few fields of corn had been cut at that time and the crop was heavily damaged. This accounts for the low yield of 6.31 tons per acre for 1913.

The best yield of silage corn for the two years was 11 tons per acre. One farm had a yield as low as 3.29 tons per acre. Four farms in 1912 and five in 1913 produced silage corn for less than $4.12 a ton.

The average distribution of the cost of raising silage corn is shown in table 15.

TABLE 15. AVERAGE DISTRIBUTION OF COST OF PRODUCING SILAGE CORN

	1912		1913	
	Average cost per acre	Per cent of total cost	Average cost per acre	Per cent of total cost
Seed	$0.70	2	$0.89	3
Fertilizer and manure	5.88	19	6.41	20
Man labor	5.85	19	6.86	21
Horse labor	8.85	28	8.67	27
Equipment labor	2.66	9	3.04	9
Use of land	3.18	10	3.39	10
Use of buildings	1.68	5	1.52	5
Filling machinery	2.08	7	1.43	4
Miscellaneous	0.39	1	0.38	1
Total cost	$31.27		$32.59	

The labor cost of raising silage corn is about 56 per cent of the total cost. The next most important costs are for fertilizer and manure, which amount to about 20 per cent of the total, and use of land, which is 10 per cent of the total. The cost for use of buildings was estimated high enough to cover interest and annual depreciation on the silo. This charge is higher than the charge for buildings of the same value used by other crops, for the annual depreciation on silos is higher than on barns. The cost of twine for binding the silage corn is included under *Miscellaneous*.

TABLE 16. AVERAGE COST OF PRODUCING SILAGE CORN UP TO THE TIME OF HARVESTING

	1912	1913
	Cost per acre	Cost per acre
Seed	$0.70	$0.89
Fertilizer and manure	5.88	6.41
Man labor	3.72	4.08
Horse labor	6.06	6.27
Equipment labor	1.78	1.88
Use of land	3.18	3.39
Total cost	$21.32	$22.92
Man hours	23.11	25.01
Horse hours	36.06	43.32

The cost of raising the corn, and the cost of harvesting and putting the corn in the silo, were separated. The point of separation was after the last cultivation. All work and expense before this was considered a part of the cost of production. The labor of harvesting the corn and filling the silo, the use of the silo-filling machinery, the twine, and the use of the silo, were considered in the cost of harvesting. The distribution of the cost up to the time of harvesting is shown in table 16, and of harvesting in table 17:

TABLE 17. AVERAGE COST OF HARVESTING SILAGE CORN AND OF FILLING SILO, INCLUDING USE OF SILO

	1912		1913	
	Cost per acre	Cost per ton	Cost per acre	Cost per ton
Man labor	$2.13	$0.26	$2.78	$0.44
Horse labor	2.79	0.35	2.40	0.38
Equipment labor	0.88	0.11	1.16	0.18
Filling machinery	2.08	0.26	1.43	0.23
Miscellaneous	0.39	0.05	0.38	0.06
Use of silo	1.68	0.21	1.52	0.24
Total cost	$9.95	$1.24	$9.67	$1.53
Man hours	14.33	1.79	16.8	2.66
Horse hours	16.88	2.11	16.11	2.55

Over one-third of the total labor on silage corn is spent in harvesting the corn and filling the silo.

In Farmers' Bulletin 578 of the United States Department of Agriculture, the cost of filling the silo is placed at 87 cents a ton. This figure, however, does not include use of ordinary equipment, use of silo, or use of silo-filling machinery. If the figures given in table 17 for these items are added to the 87 cents a ton, the result checks very closely with the total cost per ton as given in the table.

POTATOES

In 1912 and 1913 potatoes were raised on every cooperating farm. Many of the farmers, however, raised potatoes only on small acreages, for home use. Only fields of two acres or more were used in the tabulation.

The average yield of potatoes for the farms studied was 102.49 bushels in 1912 and 102.66 bushels in 1913. The average yield for the State was 106 bushels in 1912 and 74 bushels in 1913.[7] The highest yield obtained in the two years on the farms studied was 230 bushels an acre, while on three farms the yield was less than 50 bushels an acre.

[7] U. S. Agr. Dept. Yearbook 1913: 412.

The data concerning the production of potatoes are given in table 18:

TABLE 18. AVERAGES FOR POTATOES

	1912	1913
Number of farms	8	18
Total number of acres	57.5	185.4
Total yield in bushels	5,893.0	19,032.8
Yield per acre	102.49	102.66
Value per acre	$55.28	$64.09
Cost per acre	64.88	56.71
Profit or loss per acre	— 9.60	7.38
Value per bushel	$0.54	$0.62
Cost per bushel	0.63	0.55
Profit or loss per bushel	— 0.09	0.07
Profit or loss per man hour	—$0.09	$0.08
Man hours per acre	101.53	88.11
Horse hours per acre	102.26	84.50
Cost per acre aside from marketing	....	$53.74
Cost per bushel aside from marketing	....	0.52
Man hours per acre aside from marketing	....	77.68
Horse hours per acre aside from marketing	....	77.35
Pounds of commercial fertilizer per acre	....	*522

* Average for the 12 farms that used commercial fertilizer on potatoes.

The average distribution of the cost of raising potatoes is shown in table 19:

TABLE 19. AVERAGE DISTRIBUTION OF COST OF PRODUCING POTATOES

	1912		1913	
	Average cost per acre	Per cent of total cost	Average cost per acre	Per cent of total cost
Seed	$15.10	23	$ 7.67	14
Fertilizer	6.73	10	5.17	9
Manure	....	....	6.14	11
Man labor	17.26	27	14.93	26
Horse labor	14.19	22	11.66	21
Equipment labor	3.96	6	3.88	7
Use of land	4.74	7	4.53	8
Use of buildings	0.50	1	1.27	2
Sprays	1.70	3	0.83	1
Miscellaneous	0.70	1	0.63	1
Total cost	$64.88		$56.71	

Fluctuation in the value of seed constitutes a large part of the yearly fluctuation in the cost per acre of raising potatoes. Seed potatoes were much higher in 1912 than in 1913. The average amount of seed used per acre was 10.01 bushels in 1913.

One farmer used about 2000 pounds of commercial fertilizer per acre. No other farmer used more than 635 pounds per acre.

In 1912 two farmers, and in 1913 five farmers, did not spray potatoes. The highest cost of spray materials per acre was $3.75.

On six farms in 1912 and on three in 1913 no potatoes were stored and consequently there was no charge for use of buildings on these farms. One farmer had a charge of $3.33 per acre for use of buildings.

In 1913 the cost of producing potatoes was separated from the cost of marketing. Many potatoes were not marketed until after the accounts were closed. For this reason, the costs of marketing are for a smaller number of total bushels than were produced. The data concerning the cost of marketing potatoes in 1913 are given in table 20:

TABLE 20. COST OF MARKETING POTATOES, 1913

Number of farms	11
Number of bushels of potatoes	4,551
Man hours per bushel	0.43
Horse hours per bushel	0.29
Average haul in miles (round trip)	6.3
Man labor cost per bushel	$0.07
Horse labor cost per bushel	0.04
Equipment labor cost per bushel	0.01
Total cost per bushel	$0.12

OTHER CROPS

Tabulations were made for several other crops in 1913. The number of farms used in each tabulation is small, and weather conditions that year were exceptionally poor for the production of some crops. For these reasons only a few factors are given. These are presented in table 21.

Alfalfa.— On three farms alfalfa was produced in fields of 2 acres or more. On one of these there were 7.5 acres in alfalfa, on another 28 acres, and on the third 67 acres. These farms were located on limestone soil in the central part of the State, in regions where alfalfa does exceptionally well. The average yield per acre on these farms was 3.34 tons; the average yield for New York State was 2.33 tons in 1899 and 2.46 tons in 1909.[8] The number of man hours and of horse hours per

[8] Warren, G. F. Crop yields and prices, and our future food supply. Cornell Univ. Agr. Exp. Sta. Bul. 341 : 191.

acre seem to be about normal. The amount charged for use of land indicates the high value of the land on which alfalfa is produced. These factors may be typical for alfalfa grown on the better farms in the best alfalfa sections of New York State in favorable years.

TABLE 21. Averages for Several Crops for Which a Small Number of Accounts Were Kept, 1913

	Alfalfa	Barley	Beans	Buck-wheat	Cabbage	Wheat
Number of farms	3	3	2	7	4	5
Number of acres	102.5	43	83	75.6	28.6	38
Yield per acre	3.34 tons	31.9 bu.	9 bu.	14 bu.	5.2 tons	27.4 bu.
Value per acre	$53.37	$24.88	$27.28	$12.21	$105.77	$29.98
Cost per acre	20.02	26.97	24.58	18.52	45.64	29.17
Profit or loss per acre	33.35	— 2.09	2.70	— 6.31	60.13	0.81
Man hours per acre	28.56	34.74	31.73	20.35	90.92	23.67
Horse hours per acre	23.95	50.46	44.60	37.46	73.43	41.47
Cost of use of land per acre	$7.39	$4.99	$4.33	$2.53	$5.20	$3.95

Barley.— Barley was produced on three farms. The average yield was 31.9 bushels per acre; the average yield for New York State in 1913 was 26.7 bushels per acre.[9] The number of man hours and of horse hours, and the cost per acre, seem too high when compared with the average cost of producing oats.

Beans.— A heavy freeze on September 15, 1913, seriously injured the bean crop of New York State. The average yield of beans on the two farms for which results are given was only 9 bushels per acre. The average yield for New York State in 1909 was 14.5 bushels.[10]

Buckwheat.— Buckwheat was produced on seven farms. This crop also was seriously injured by the freeze of September 15. The average yield for these seven farms was 14 bushels per acre. The average yield per acre for the whole State was 14.3 bushels in 1913, and was 18.8 bushels per acre for the ten years from 1900 to 1909.[11]

Cabbage.— The year 1913 was unfavorable for the growth of cabbage. The average yield on the four farms tabulated was 5.2 tons per acre. This is a little more than half the normal yield. The price received per ton was more than enough to make up for the low yield, and the profit per

[9] U. S. Agr. Dept. Yearbook **1913**: 397.
[10] Thirteenth Census of the United States **7**: 210. 1910.
[11] U. S. Agr. Dept. Yearbook **1913**: 407.

acre was abnormally high. The man hours and the horse hours per acre, and the cost per acre, were probably lower than the normal because of the small tonnage harvested.

Wheat.— The wheat tabulation included five farms with 38 acres. The average yield was 27.4 bushels per acre; the average yield for the State was 20 bushels per acre for 1913, and was 17.4 bushels for the ten years from 1900 to 1909.[12] The number of man hours and of horse hours per acre, and the cost per acre, were probably too high to be typical.

DAIRY COWS

Dairy cows are the most important livestock kept on New York farms. Seven farms in 1912, and twenty-two farms in 1913, had herds of five or more cows and were used in the tabulations. The herds on one of these farms in 1912 and on five in 1913 were purebreds. All these cattle were of the Holstein-Friesian breed, which was also the predominating breed among the grade cattle.

The principal products sold from the dairy farms were milk and stock. Milk was sold largely as market milk, to be shipped to the large cities. Small quantities of cream, butter, creamery milk, and cheese factory milk, were sold.

Most of the results were calculated on the cattle unit basis. One cow, one bull, or two head of young stock, were counted as one cattle unit. The smallest herd used in the tabulations had an average of 5.5 cows; the largest herd averaged 40.5 cows. Both these herds showed a profit. The data are given in table 22. The results of the dairy accounts for 1912 and 1913 are summarized in tables 23 and 24, respectively.

TABLE 22. DAIRY COWS

	1912		1913	
	Grades	Purebreds	Grades	Purebreds
Number of farms	6	1	17	5
Number of cows	111.0	18.5	297.5	110.5
Number of cattle units	174.2	25.0	406.33	163.75
Average number of cows per farm	18.5	18.5	17.5	22.1
Average number of cattle units per farm	29.03	25.00	23.90	32.75
Average value per cow	$72.23	$211.49	$71.10	$215.90
Average value per cattle unit	70.14	201.00	67.32	224.10

[12] U. S. Agr. Dept. Yearbook 1913: 382.

TABLE 23. Summary of Results of Dairy Accounts for 1912

	Grade herds			Purebred herds		
	Total	Per cattle unit	Per cent of total	Total	Per cattle unit	Per cent of total
Costs						
Forage (except silage)	$2,298.85	$ 13.20	16	$ 384.45	$15.38	12
Bedding	268.50	1.54	2	53.06	2.12	2
Silage	2,509.70	14.41	18	603.00	24.12	18
Grain	3,431.89	19.70	24	1,017.13	40.68	31
Pasture	1,000.00	5.74	7	50.00	2.00	2
Veterinary fees and medicine	35.47	0.20	......	43.79	1.75	1
Man labor	2,921.37	16.77	21	645.73	25.83	20
Horse labor	425.31	2.44	3	58.85	2.35	2
Equipment labor	144.38	0.83	1	14.71	0.59	....
Use of buildings	378.00	2.17	3	80.00	3.20	2
Interest	613.67	3.52	4	251.25	10.05	8
Miscellaneous	203.63	1.17	1	70.66	2.83	2
Total cost	$14,230.77	$81.69	......	$3,272.63	$130.90	....
Returns						
Manure	$1,475.50	$ 8.47	......	$ 120.00	$ 4.80	....
Milk — per grade cow, $82.88	9,200.26	......	......	....	......	....
Milk — per purebred cow, $92.16	....	......	......	1,704.91	......	....
Cattle increase and net sales	3,598.34	20.66	......	2,487.26	99.49	....
Miscellaneous receipts	31.55	0.18	......	....	......	....
Total returns	$14,305.65	$82.12	......	$4,312.17	$172.49	....
Profit	$74.88	$0.43	......	$1,039.54	$41.59	....

The total cost of keeping a cattle unit of grade stock was $81.69 in 1912, and $92.01 in 1913; the total cost of keeping a cattle unit of purebred stock was $130.90 in 1912, and $139.90 in 1913. Grade cows produced milk to the value of $82.88 per cow in 1912, and $99.47 per cow in 1913; the value of the milk produced by purebreds was $92.16 per cow in 1912, and $107.72 per cow in 1913.

The greatest difference in returns from grade and purebred stock was in the cattle increase and net sale. This factor was found by adding together the last cattle inventory and the cattle sold, and subtracting from this total the sum of the first cattle inventory and the cattle purchased. Cattle increase and net sales for grade stock amounted to $20.66 per cattle unit in 1912, and $18.02 per cattle unit in 1913; for purebred stock this item was $99.49 per cattle unit in 1912, and $87.06 per cattle unit in 1913.

TABLE 24. SUMMARY OF RESULTS OF DAIRY ACCOUNTS FOR 1913

	Grade herds			Purebred herds		
	Total	Per cattle unit	Per cent of total	Total	Per cattle unit	Per cent of total
Costs						
Forage (except silage)	$7,112.04	$17.50	19	$3,766.51	$23.00	16
Bedding	902.95	2.22	3	418.46	2.56	2
Silage	5,329.70	13.12	14	2,347.10	14.33	10
Grain	9,229.94	22.71	25	5,597.74	34.18	25
Pasture	2,014.49	4.96	5	740.65	4.52	3
Veterinary fees and medicine	82.69	0.20	......	90.75	0.55	....
Man labor	7,827.16	19.26	21	4,563.23	27.87	20
Horse labor	1,071.08	2.64	3	526.47	3.22	2
Equipment labor	370.28	0.91	1	158.57	0.97	1
Use of buildings	1,143.17	2.81	3	384.00	2.35	2
Interest	1,442.10	3.55	4	1,836.58	11.22	8
Miscellaneous	866.07	2.13	2	2,478.09	15.13	11
Total cost	$37,391.67	$92.01	......	$22,908.15	$139.90	....
Returns						
Manure	$4,306.50	$10.60	......	$1,655.00	$10.11	....
Milk — per grade cow, $99.47	29,591.32	......	......	....	......	....
Milk — per purebred cow, $107.72	....	......	......	11,902.51	......	....
Cattle increase and net sales	7,323.96	18.02	......	14,256.67	87.06	....
Miscellaneous receipts	159.77	0.39	......	293.03	1.79	....
Total returns	$41,381.55	$101.84	......	$28,107.21	$171.65	....
Profit	$3,989.88	$9.83	......	$5,199.06	$31.75	....

The total returns per cattle unit for grade stock were $82.12 in 1912, and $101.84 in 1913; for purebreds this figure amounted to $172.49 in 1912, and $171.65 in 1913. The profit per cattle unit on grade cattle was 43 cents in 1912, and $9.83 in 1913; on purebreds it was $41.59 in 1912, and $31.75 in 1913.

The total food and bedding cost per cattle unit for grade stock was $54.59 in 1912, and $60.51 in 1913; for purebreds it was $84.30 in 1912, and $78.59 in 1913. In 1913 this item constituted 66 per cent of the total cost of keeping grade cattle, and 56 per cent of the cost of keeping purebred cattle.

The man labor charge was much higher for purebreds than for grade stock. The charges for veterinary service and medicine, and for interest, were also higher for purebred than for grade cattle.

The average quantities of feed given the herds, the amount of labor required for their care, and the amount of milk produced, are given in table 25:

TABLE 25. Average Amounts of Feed Used, Labor Required, and Milk Produced, for Dairy Cows

	1912		1913	
	Grade cows	Purebreds	Grade cows	Purebreds
Pounds of straw for feed and bedding per cattle unit	617	160	779	798
Pounds of silage per cattle unit	*6,152	10,320	6,737	6,791
Pounds of other forage per cattle unit	*1,865	2,800	3,190	3,216
Pounds of grain per cattle unit	1,313	2,660	1,551	2,339
Man hours per cattle unit	117	130	116	161
Horse hours per cattle unit	13	19	19	23
Pounds of milk per cow	....	....	†7,926	‡8,222

* One farm did not feed silage and was omitted from this average.
† Average for 13 out of 17 herds.
‡ Average for 2 out of 5 herds.

It is shown in table 25 that purebred cattle were fed more than grade cattle, and more man hours and more horse hours were required to care for a cattle unit of purebreds than for a cattle unit of grade stock. Purebreds gave more milk per cow than did grade stock.

It should be observed that the grade cows on the cooperating farms were much better than the average New York State cow. The grade herds in the 1913 tabulation produced an average of 7926 pounds of milk per cow, whereas the average production per cow for the State was 4463 pounds in 1909.[13]

DISTRIBUTION OF LABOR

BY ENTERPRISES

All labor was first classified under labor fixed as to season, and labor not fixed as to season. Plowing, hauling fertilizer, threshing, and cleaning seed, were considered as labor not fixed as to season. Fitting the ground, planting, harvesting, cultivating, spraying, and rolling, were considered as labor fixed as to season. Marketing was not included in any of the tables. Work on cows was all considered as fixed labor. This was separated into labor on chores or other work, and milk hauling.

[13] Thirteenth Census of the United States 7 : 205. 1910.

All labor was classified also by ten-days periods, each month being divided into three periods. From the 1st day of the month to the 10th, inclusive, was called the first period; from the 11th to the 20th day, inclusive, was called the second period; from the 21st to the last day of the month, inclusive, was called the third period.

Probably a greater proportion of fall plowing was done than is indicated by the tables. The year 1913 was the first year for which accounts were kept on several of the farms. Data from some farms could not be used in these tabulations, because fall plowing had been done, of which there was no record.

Only those farms were used in the tabulations that had a growing season typical of central New York. Farms from the extreme north or south of the State were not used. The data for man labor are contained in tables 26 to 31, inclusive, and the data for horse labor in tables 32 to 36, inclusive.

TABLE 26. DISTRIBUTION OF MAN LABOR PER ACRE ON TIMOTHY AND CLOVER BY OPERATIONS AND BY TEN-DAYS PERIODS. FIFTEEN FARMS, 662.9 ACRES, 1913

Month	Period	Hours of labor fixed as to season*	Hours of labor not fixed as to season*	Total number of hours
January	1	....	.01	.01
	2	....	....	....
	3	....	....	....
February	1	....	....	....
	2	....	....	....
	3	....	....	....
March	1	....	....	....
	2	....	.01	.01
	3	....	....	....
April	1	....	.05	.05
	2	....	.09	.09
	3	....	.02	.02
May	1	....	.01	.01
	2	....	....	....
	3	....	.01	.01
June	1	....	.02	.02
	2	....	.02	.02
	3	.13	....	.13
July	1	1.72	....	1.72
	2	3.78	....	3.78
	3	3.01	....	3.01
August	1	.84	....	.84
	2	....	....	....
	3	....	....	....
September	1	....	....	....
	2	....	.01	.01
	3	....	....	....
October	1	....	....	....
	2	....	.02	.02
	3	....	.01	.01
Total	......	9.48	.28	9.76

* The fixed labor was all harvesting. The labor not fixed was seeding, rolling, and other miscellaneous operations.

TABLE 27. DISTRIBUTION OF MAN LABOR PER ACRE ON OATS BY OPERATIONS AND BY TEN-DAYS PERIODS. TEN FARMS, 209.4 ACRES, 1913

Month	Period	Hours											
		Plowing	Fitting	Planting	Harvesting	Threshing	Cleaning seed	Rolling	Hauling fertilizer, etc.	Hauling seed	Total fixed as to season	Total not fixed as to season	Total
January	1	......	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	.03	......	......	......	......	.03	.03
	3	......	......	......	......	......	.02	......	......	......	......	.02	.02
February	1	......	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......	......
March	1	......	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......	......
	3	.18	......	......	......	......	.02	......	......	......	......	.20	.20
April	1	.79	.02	......	......	......	......	......	.02	......	.02	.81	.83
	2	1.76	.41	.07	......	......	.07	......	......	......	.48	1.83	2.31
	3	1.62	1.03	.35	......	......	.21	.04	......	.01	1.42	1.84	3.26
May	1	.69	1.93	.88	......	......	.01	.30	.09	.01	3.11	.80	3.91
	2	.10	.16	.09	......	......	......	.05	......	......	.30	.10	.40
	3	......	.04	.06	......	......	......	.02	......	......	.12	......	.12
June	1	......	......	......	......	......	......	.02	......	......	.02	......	.02
	2	......	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......	......
July	1	......	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	.16	.01	......	......	......	......	.16	.01	.17
August	1	......	......	......	2.83	.07	......	......	......	......	2.83	.07	2.90
	2	......	......	......	3.68	.25	......	......	......	......	3.68	.25	3.93
	3	......	......	......	.60	.60	......	......	......	......	.60	.60	1.20
September	1	......	......	......	......	1.00	......	......	......	......	......	1.00	1.00
	2	......	......	......	......	......	......	......	.07	......	......	.07	.07
	3	......	......	......	......	.01	......	......	......	......	......	.01	.01
October	1	......	......	......	......	.78	......	......	......	......	......	.78	.78
	2	......	......	......	......	.06	......	......	......	......	......	.06	.06
	3	......	......	......	......	.55	......	......	......	......	......	.55	.55

November	1	....	....	....	....	.09	....	....	....	....	....	.09	.09
	2	.45	....	....	....	....	....	....	....	....	....	.45	.45
	3	.10	....	....	....	....	....	....	....	....	....	.10	.10
December	1	....	....	....	....	....	....	....	.07	....	....	.07	.07
	2	....	....	....	....	....	....	....	....	....	....	....	....
	3	....	....	....	....	....	....	....	....	....	....	....	....
Total	......	5.69	3.59	1.45	7.27	3.42	.36	.43	.25	.02	12.74	9.74	22.48

TABLE 28. Distribution of Man Labor per Acre on Silage Corn by Operations and by Ten-Days Periods. Seven Farms, 70.1 Acres, 1913

Month	Period	Hours: Plowing	Fitting	Planting	Cultivating	Harvesting	Hauling fertilizer, etc.	Total fixed as to season	Total not fixed as to season	Total
March	1	....	....	....	....	....	....	....	....	....
	2	.07	....	....	....	....	....	....	.07	.07
	3	.32	....	....	....	....	....	....	.32	.32
April	1	.41	....	....	....	....	....	....	.41	.41
	2	....	.02	....	....	....	.02	.02	.02	.04
	3	.14	....	....	....	....	....	....	.14	.14
May	1	1.69	.10	....	....	....	....	.10	1.69	1.79
	2	.81	1.05	.17	....	....	....	1.22	.81	2.03
	3	2.00	1.55	.40	....	....	.02	1.95	2.02	3.97
June	1	.12	1.05	.59	....	....	.04	1.64	.16	1.80
	2	.19	.42	.37	2.23	....	....	3.02	.19	3.21
	3	....	.04	....	1.89	....	....	1.93	....	1.93
July	1	....	....	....	1.75	....	....	1.75	....	1.75
	2	....	....	....	1.46	....	....	1.46	....	1.46
	3	....	....	....	1.99	....	....	1.99	....	1.99
August	1	....	....	....	.23	....	....	.23	....	.23
	2	....	....	....	.58	....	....	.58	....	.58
	3	....	....	....	....	....	....	....	....	....
September	1	....	....	....	....	....	....	....	....	....
	2	....	....	....	....	1.48	....	1.48	....	1.48
	3	....	....	....	....	9.99	....	9.99	....	9.99

October	1	....	....	....	....	3.09	....	3.09	....	3.09
	2	....	....	....	....	.29	....	.29	....	.29
	3	....	....	....	....	....	....	....	....	....
November	1	....	....	....	....	....	....	....	....	....
	2	....	....	....	....	....	....	....	....	....
	3	.61	....	....	....	....	....	....	.61	.61
Total	......	6.36	4.23	1.53	10.13	14.85	.08	30.74	6.44	37.18

TABLE 29. DISTRIBUTION OF MAN LABOR PER ACRE ON POTATOES BY OPERATIONS AND BY TEN-DAYS PERIODS. SIX FARMS, 108.5 ACRES, 1913

Month	Period	Hours: Plowing	Fitting	Planting	Cultivating	Harvesting	Hauling fertilizer, etc.	Drilling fertilizer	Spraying	Total fixed as to season	Total not fixed as to season	Total
February	1	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	.16	......	......	......	.16	.16
March	1	......	......	......	......	......	.05	......	......	......	.05	.05
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......
April	1	.60	......	......	......	......	......	......	......	......	.60	.60
	2	.42	.06	......	......	......	......	......	......	.06	.42	.48
	3	1.24	.08	.05	......	......	......	......	......	.13	1.24	1.37
May	1	.30	.65	.24	......	......	.12	......	......	.89	.42	1.31
	2	2.07	1.35	1.85	......	......	.09	.24	......	3.44	2.16	5.60
	3	.87	.32	1.92	......	......	......	.09	......	2.33	.87	3.20
June	1	.24	1.76	4.24	......	......	......	.23	......	6.23	.24	6.47
	2	.17	.76	3.54	1.26	......	......	......	......	5.56	.17	5.73
	3	.07	.35	.45	2.04	......	......	......	......	2.84	.07	2.91
July	1	.37	.06	......	1.65	......	......	.03	.32	2.06	.37	2.43
	2	.06	.06	......	1.98	......	......	......	.15	2.19	.06	2.25
	3	......	.05	.08	2.59	......	......	......	.18	2.90	......	2.90
August	1	......	......	......	2.74	......	......	......	.53	3.27	......	3.27
	2	......	......	......	.87	......	......	......	......	.87	......	.87
	3	......	......	......	.32	......	......	......	......	.32	......	.32

September.........	1	......	......	......	.35	......	......	......	......	.35	......	.35
	2	......	......	......	.04	......	......	......	......	.04	......	.04
	3	......	......	......	......	.97	......	......	......	.97	......	.97
October...........	1	......	......	......	......	4.94	......	......	......	4.94	......	4.94
	2	......	......	......	......	6.03	......	......	......	6.03	......	6.03
	3	......	......	......	......	7.69	......	......	......	7.69	......	7.69
November.........	1	......	......	......	......	6.13	......	......	......	6.13	......	6.13
	2	......	......	......	......	1.70	......	......	......	1.70	......	1.70
	3	......	......	......	......	......	......	......	......	......	......	......
Total.........	......	6.41	5.50	12.37	13.84	27.46	.42	.59	1.18	60.94	6.83	67.77

TABLE 30. DISTRIBUTION OF MAN LABOR PER ACRE ON BUCKWHEAT BY OPERATIONS AND BY TEN-DAYS PERIODS. FIVE FARMS, 66.6 ACRES, 1913

Month	Period	Hours										
		Plowing	Fitting	Planting	Harvesting	Threshing	Rolling	Hauling fertilizer, etc.	Hauling seed	Total fixed as to season	Total not fixed as to season	Total
May	1	.78	......	......	......	......	......	......	......	......	.78	.78
	2	.51	.47	......	......	......	......	......	......	.47	.51	.98
	3	.90	.23	.20	......	......	......	......	......	.43	.90	1.33
June	1	.35	......	......	......	......	......	.14	......	......	.49	.49
	2	2.15	.45	.18	......	......	.04	......	......	.67	2.15	2.82
	3	1.10	.55	.18	......	......	......	......	.56	.73	1.66	2.39
July	1	......	1.05	1.16	......	......	.29	......	......	2.50	......	2.50
	2	......	......	.04	......	......	......	......	......	.04	......	.04
	3	......	......	......	......	......	......	......	......	......	......	......
August	1	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......
September	1	......	......	......	.65	......	......	......	......	.65	......	.65
	2	......	......	......	1.40	......	......	......	......	1.40	......	1.40
	3	......	......	......	.87	......	......	......	......	.87	......	.87
October	1	......	......	......	.63	1.39	......	......	......	.63	1.39	2.02
	2	......	......	......	......	.03	......	......	......	......	.03	.03
	3	......	......	......	......	......	......	......	......	......	......	......

November........	1	......	......	......	......	.15	......	......	......	......	.15	.15
	2	......	......	......	......	......	......	......	......	......	......	....
	3	......	......	......	......	......	......	......	......	......	......	....
Total.........	......	5.79	2.75	1.76	3.55	1.57	.33	.14	.56	8.39	8.06	16.45

TABLE 31. DISTRIBUTION OF MAN LABOR PER CATTLE UNIT ON GRADE COWS BY OPERATIONS AND BY TEN-DAYS PERIODS. FIVE FARMS, 173.25 CATTLE UNITS, 1913

Month	Period	Hours: Chores and other work	Hours: Hauling milk
January	1	4.17	.36
	2	3.95	.34
	3	4.16	.40
February	1	3.77	.38
	2	4.11	.34
	3	3.73	.22
March	1	4.35	.42
	2	4.17	.28
	3	4.90	.36
April	1	4.23	.40
	2	3.88	.37
	3	3.68	.34
May	1	3.26	.36
	2	3.08	.39
	3	3.15	.39
June	1	2.77	.31
	2	2.52	.34
	3	2.55	.30
July	1	2.65	.32
	2	2.57	.35
	3	2.65	.44
August	1	2.14	.33
	2	2.03	.33
	3	2.47	.38
September	1	2.24	.38
	2	2.25	.35
	3	2.26	.32
October	1	2.27	.34
	2	2.76	.37
	3	3.12	.35
November	1	3.09	.32
	2	3.15	.35
	3	3.34	.33
December	1	3.55	.34
	2	3.72	.32
	3	4.17	.40
Total	......	116.86	12.62

TABLE 32. DISTRIBUTION OF HORSE LABOR PER ACRE ON TIMOTHY AND CLOVER BY OPERATIONS AND BY TEN-DAYS PERIODS. FIFTEEN FARMS, 662.9 ACRES, 1913

Month	Period	Hours of labor fixed as to season*	Hours of labor not fixed as to season	Total number of hours
March	1	....	....	....
	2	....	....	....
	3	....	.01	.01
April	1	....	.03	.03
	2	....	.17	.17
	3	....	.04	.04
May	1	....	.02	.02
	2	....	....	....
	3	....	.02	.02
June	1	....	.02	.02
	2	....	.02	.02
	3	.18	....	.18
July	1	1.73	....	1.73
	2	3.58	....	3.58
	3	3.03	....	3.03
August	1	.62	....	.62
	2	....	....	....
	3	....	....	....
September	1	....	....	....
	2	....	.01	.01
	3	....	....	....
October	1	....	....	....
	2	....	....	....
	3	....	.01	.01
Total	......	9.14	.35	9.49

*The fixed labor was all harvesting. The labor not fixed was seeding, rolling, and other miscellaneous operations.

TABLE 33. DISTRIBUTION OF HORSE LABOR PER ACRE ON OATS BY OPERATIONS AND BY TEN-DAYS PERIODS. TEN FARMS, 209.4 ACRES, 1913

Month	Period	Hours										
		Plowing	Fitting	Planting	Harvesting	Threshing	Cleaning seed	Rolling	Hauling fertilizer	Total fixed as to season	Total not fixed as to season	Total
March	1	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......
	3	.38	......	......	......	......	......	......	......	......	.38	.38
April	1	1.65	.02	......	......	......	......	......	.07	.02	1.72	1.74
	2	3.68	1.02	.07	......	......	......	......	......	1.09	3.68	4.77
	3	3.38	2.65	.53	......	......	.01	.08	......	3.26	3.39	6.65
May	1	1.66	4.27	1.69	......	......	......	.60	.06	6.56	1.72	8.28
	2	.20	.53	.19	......	......	......	.10	......	.82	.20	1.02
	3	......	.12	.11	......	......	......	.04	......	.27	......	.27
June	1	......	......	......	......	......	......	.05	......	.05	......	.05
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......
July	1	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	.19	.02	......	......	......	.19	.02	.21
August	1	......	......	......	2.75	......	......	......	......	2.75	......	2.75
	2	......	......	......	3.41	.04	......	......	......	3.41	.04	3.45
	3	......	......	......	.52	.03	......	......	......	.52	.03	.55
September	1	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	.02	......	.02	.02
	3	......	......	......	......	......	......	......	......	......	......	......

October..........	1	......	......	......	......	.08	......	......	......	......	.08	.08
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	.04	......	......	......	......	.04	.04
November.........	1	......	......	......	......	......	......	......	......	......	......	......
	2	.86	......	......	......	......	......	......	......	......	.86	.86
	3	.20	......	......	......	......	......	......	......	......	.20	.20
December.........	1	......	......	......	......	......	......	......	.07	......	.07	.07
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......
Total.........	......	12.01	8.61	2.59	6.87	.21	.01	.87	.22	18.94	12.45	31.39

TABLE 34. DISTRIBUTION OF HORSE LABOR PER ACRE ON SILAGE CORN BY OPERATIONS AND BY TEN-DAYS PERIODS. SEVEN FARMS, 70.1 ACRES, 1913

Month	Period	Hours								
		Plowing	Fitting	Planting	Cultivating	Harvesting	Hauling fertilizer	Total fixed as to season	Total not fixed as to season	Total
March	1	....	....	....	....	....	....	....	....	....
	2	.11	....	....	....	....	....	....	.11	.11
	3	1.13	....	....	....	....	....	....	1.13	1.13
April	1	1.16	....	....	....	....	....	....	1.16	1.16
	2	....	.06	....	....	....	.05	.06	.05	.11
	3	.43	....	....	....	....	....	....	.43	.43
May	1	3.43	.19	....	....	....	....	.19	3.43	3.62
	2	2.44	2.62	.23	....	....	....	2.85	2.44	5.29
	3	5.80	4.69	.71	....	....	.04	5.40	5.84	11.24
June	1	.34	3.12	1.23	....	....	.11	4.35	.45	4.80
	2	.57	1.18	.34	3.43	....	....	4.95	.57	5.52
	3	....	.13	....	2.87	....	....	3.00	....	3.00
July	1	....	....	....	2.69	....	....	2.69	....	2.69
	2	....	....	....	2.18	....	....	2.18	....	2.18
	3	....	....	....	3.10	....	....	3.10	....	3.10
August	1	....	....	....	.23	....	....	.23	....	.23
	2	....	....	....	.61	....	....	.61	....	.61
	3	....	....	....	....	....	....	....	....	....
September	1	....	....	....	....	....	....	....	....	....
	2	....	....	....	....	2.11	....	2.11	....	2.11
	3	....	....	....	....	10.75	....	10.75	....	10.75

October..........	1	....	....	....	....	2.52	....	2.52	....	2.52
	2	....	....	....	....	.29	....	.29	....	.29
	3	....	....	....	....	....	....	....	....	....
November.......	1	....	....	....	....	....	....	....	....	....
	2	....	....	....	....	....	....	....	....	....
	3	1.51	....	....	....	....	....	....	1.51	1.51
Total........	......	16.92	11.99	2.51	15.11	15.67	.20	45.28	17.12	62.40

TABLE 35. DISTRIBUTION OF HORSE LABOR PER ACRE ON POTATOES BY OPERATIONS AND BY TEN-DAYS PERIODS. SIX FARMS, 108.5 ACRES, 1913

Month	Period	Hours										
		Plowing	Fitting	Planting	Cultivating	Harvesting	Hauling fertilizer	Drilling fertilizer	Spraying	Total fixed as to season	Total not fixed as to season	Total
February	1	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	.31	......	......	......	.31	.31
March	1	......	......	......	......	......	.09	......	......	......	.09	.09
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......
April	1	1.29	......	......	......	......	......	......	......	......	1.29	1.29
	2	.83	.11	......	......	......	......	......	......	.11	.83	.94
	3	2.53	.22	.09	......	......	......	......	......	.31	2.53	2.84
May	1	.67	1.40	.02	......	......	.22	......	......	1.42	.89	2.31
	2	4.88	3.26	1.49	......	......	.23	.50	......	5.25	5.11	10.36
	3	2.25	.77	1.12	......	......	......	.18	......	2.07	2.25	4.32
June	1	.55	3.86	2.57	......	......	......	.46	......	6.89	.55	7.44
	2	.47	1.70	1.89	1.31	......	......	......	......	4.90	.47	5.37
	3	.22	.79	.29	3.12	......	......	......	......	4.20	.22	4.42
July	1	.43	.13	......	2.10	......	......	.06	.28	2.57	.43	3.00
	2	.13	.17	......	2.71	......	......	......	......	2.88	.13	3.01
	3	......	.14	.07	1.90	......	......	......	.17	2.28	......	2.28
August	1	......	......	......	1.51	......	......	......	.68	2.19	......	2.19
	2	......	......	......	.24	......	......	......	......	.24	......	.24
	3	......	......	......	.33	......	......	......	......	.33	......	.33

September........	1	......	......	......	.18	......	......	......	......	.18	......	.18
	2	......	......	......	.04	......	......	......	......	.04	......	.04
	3	......	......	......	......	.74	......	......	......	.74	......	.74
October...........	1	......	......	......	......	2.27	......	......	......	2.27	......	2.27
	2	......	......	......	......	3.57	......	......	......	3.57	......	3.57
	3	......	......	......	......	4.71	......	......	......	4.71	......	4.71
November........	1	......	......	......	......	3.94	......	......	......	3.94	......	3.94
	2	......	......	......	......	1.76	......	......	......	1.76	......	1.76
	3	......	......	......	......	......	......	......	......	......	......	....
Total.........	......	14.25	12.55	7.54	13.44	16.99	.85	1.20	1.13	52.85	15.10	67.95

TABLE 36. Distribution of Horse Labor per Acre on Buckwheat by Operations and by Ten-Days Periods. Five Farms, 66.6 Acres, 1913

Month	Period	Hours										
		Plowing	Fitting	Planting	Harvesting	Threshing	Rolling	Hauling fertilizer	Hauling seed	Total fixed as to season	Total not fixed as to season	Total
May	1	2.10	......	......	......	......	......	......	......	......	2.10	2.10
	2	1.48	1.23	......	......	......	......	......	......	1.23	1.48	2.71
	3	2.51	.54	......	......	......	......	......	......	.54	2.51	3.05
June	1	.71	......	......	......	......	......	.09	......	......	.80	.80
	2	5.91	1.10	.36	......	......	.09	......	......	1.55	5.91	7.46
	3	2.46	1.12	.15	......	......	......	......	1.17	1.27	3.63	4.90
July	1	......	2.78	1.94	......	......	.27	......	......	4.99	......	4.99
	2	......	......	.09	......	......	......	......	......	.09	......	.09
	3	......	......	......	......	......	......	......	......	......	......	......
August	1	......	......	......	......	......	......	......	......	......	......	......
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......
September	1	......	......	......	.95	......	......	......	......	.95	......	.95
	2	......	......	......	2.09	......	......	......	......	2.09	......	2 09
	3	......	......	......	.74	......	......	......	......	.74	......	.74
October	1	......	......	......	.69	1.11	......	......	......	.69	1.11	1.80
	2	......	......	......	......	......	......	......	......	......	......	......
	3	......	......	......	......	......	......	......	......	......	......	......
Total	......	15.17	6.77	2.54	4.47	1.11	.36	.09	1.17	14.14	17.54	31.68

BY FARMS

The following charts (Figs. 132–134) show the distribution of man labor on three farms with different types of farming:

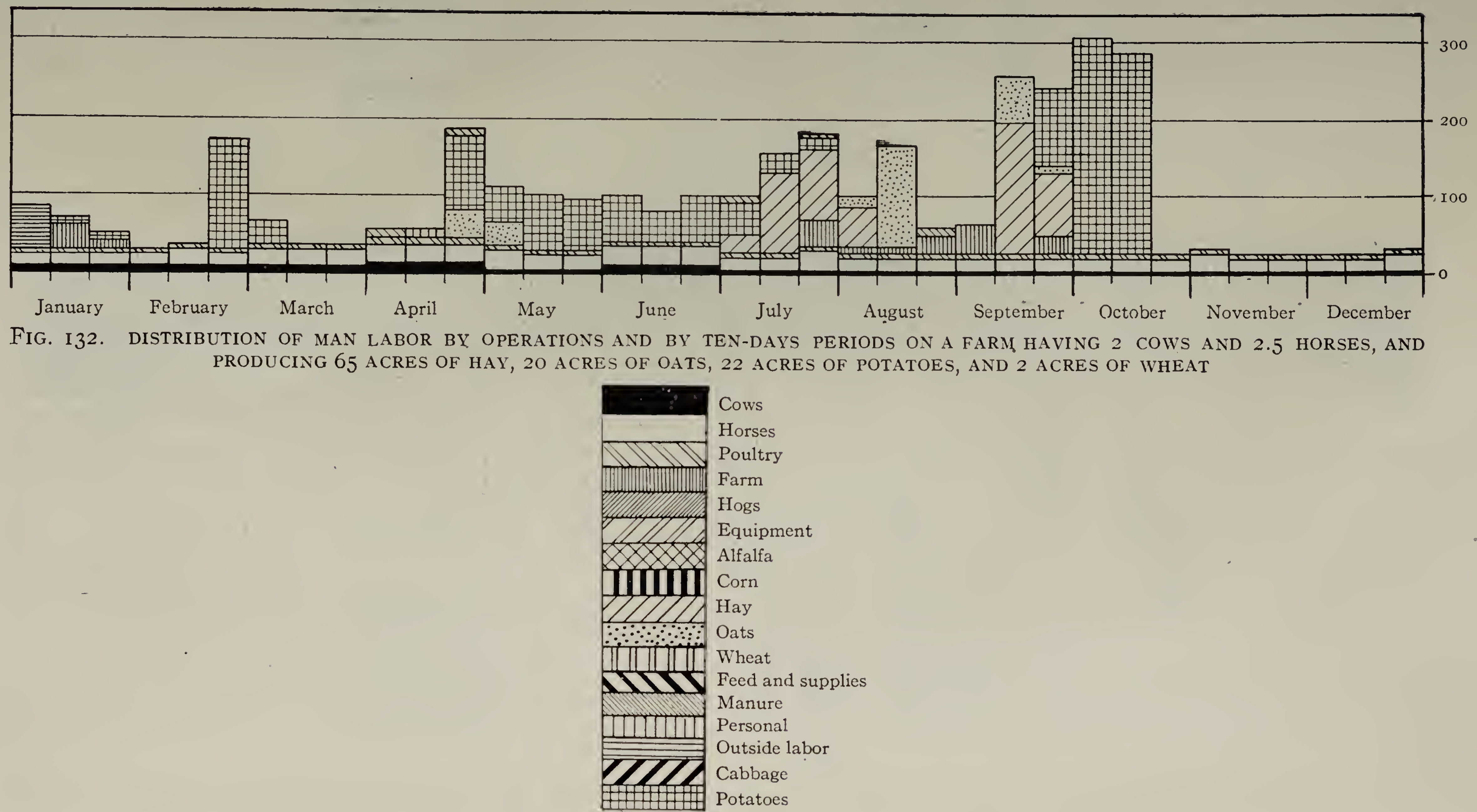


FIG. 132. DISTRIBUTION OF MAN LABOR BY OPERATIONS AND BY TEN-DAYS PERIODS ON A FARM HAVING 2 COWS AND 2.5 HORSES, AND PRODUCING 65 ACRES OF HAY, 20 ACRES OF OATS, 22 ACRES OF POTATOES, AND 2 ACRES OF WHEAT

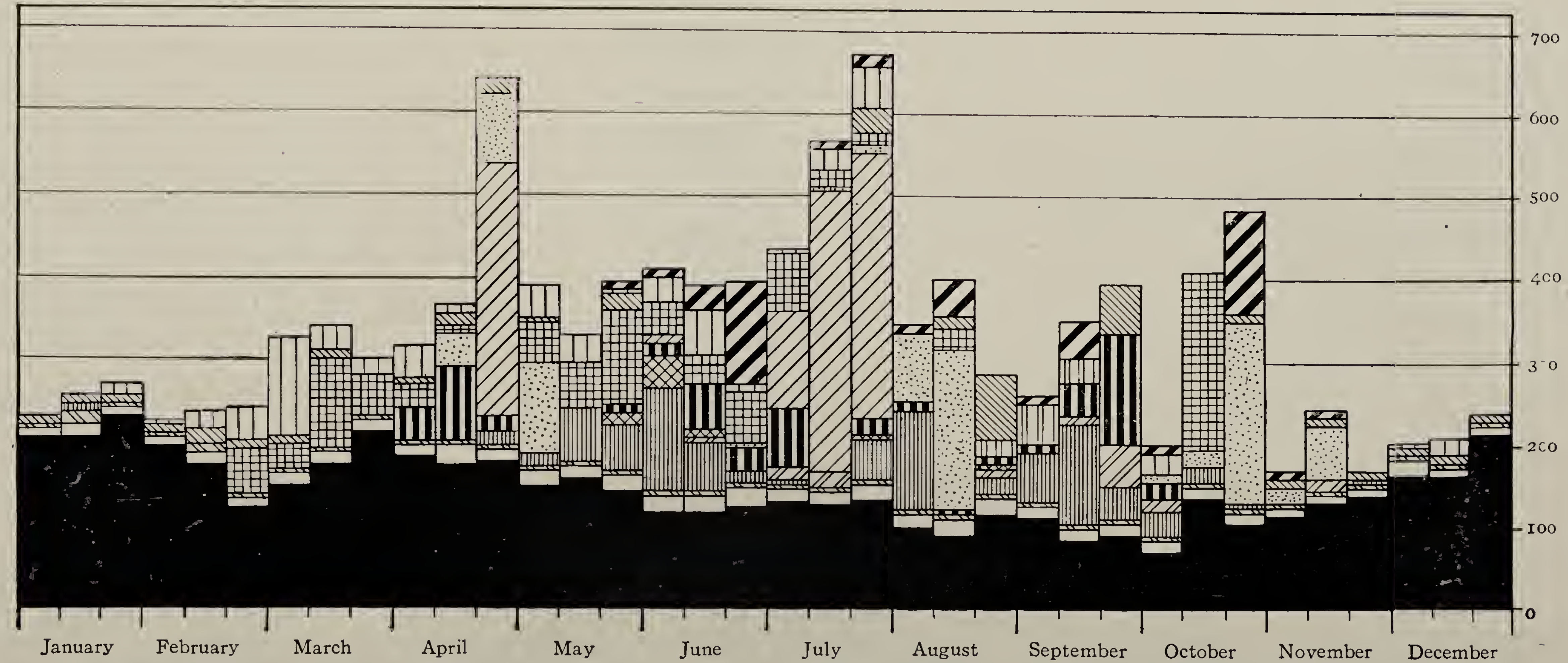
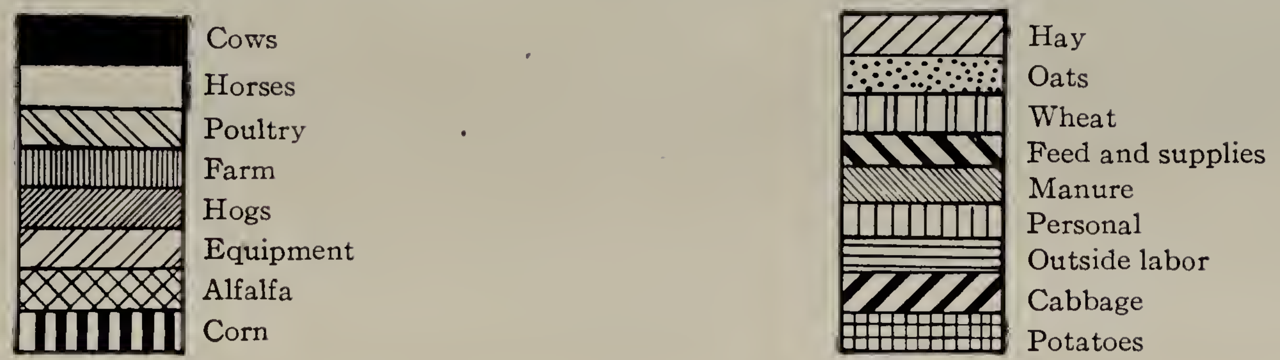


FIG. 133. DISTRIBUTION OF MAN LABOR BY OPERATIONS AND BY TEN-DAYS PERIODS ON A FARM HAVING 40.5 COWS AND 9 HORSES, AND PRODUCING 10.7 ACRES OF POTATOES, 43.8 ACRES OF OATS, 19.2 ACRES OF SILAGE CORN, 6.7 ACRES OF CABBAGE, AND 101.7 ACRES OF HAY



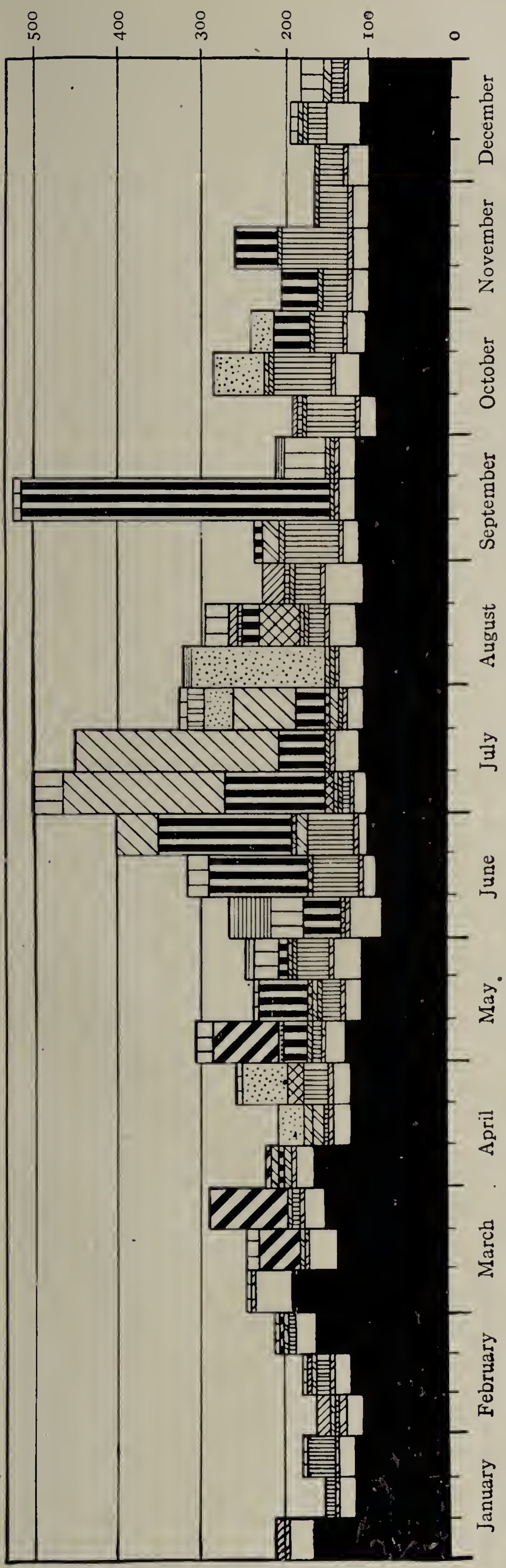


FIG. 134. DISTRIBUTION OF MAN LABOR BY OPERATIONS AND BY TEN-DAYS PERIODS ON A FARM HAVING 15.5 COWS AND 4 HORSES, AND PRODUCING 55 ACRES OF HAY, 17 ACRES OF OATS, AND 18.5 ACRES OF SILAGE CORN